MATHEMATICS IN POPULAR CULTURE:

AN ANALYSIS OF MATHEMATICAL INTERNET MEMES

by

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ABSTRACT

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Popular culture has had a great deal of impact on our social, cultural, and political worlds; it is portrayed through different mediums, in different forms, and connects the world to ideas, beliefs, and different perspectives. Though this dissertation is part of a larger body of work that examines the complex relationship between popular culture and mathematical identity, this study takes a different perspective by examining it through the lens of mathematical Internet memes. This study was conducted with 31 secondary school participants and used a two-tiered approach (in-depth focus groups and an individual meme activity) at each of the five school sites visited around New York City.

Multiple sources of data were used to reveal that students are receiving messages about mathematics from memes in popular culture. In particular, participants described six core themes from the meme inventory: (1) stereotypical views of mathematics; (2) mathematics is too complicated; (3) no effort should be needed in mathematics; (4) mathematics is useless; (5) mathematics is not fun; and (6) sense of accomplishment from mathematics. Participants were also given free rein to create hypothetical mathematics memes. Findings demonstrate that not only are memes being used to depict mathematical stereotypes, thereby reinforcing negative messages, but also support social media practices (liking, commenting, sharing, and creating) that reify negative messages about mathematics with little to no resistance from opposing

perspectives. In general, participants described mathematical memes in a specific manner that demonstrates them having influence over students' mathematical identity but not entirely on the way one may think. Future research implications include explorations of the "new" online mathematical space students are utilizing; to wit, what makes these specific memes go viral? What are common misconceptions? Are commenters learning from their mistakes and other answer responses?

Implications for practice include the creation of formal spaces within classrooms and communities for students to debrief their thoughts and sentiments about mathematics, as well as informal opportunities for educators, students, and community members to engage positively about mathematics: because without these interventions the messages found in memes, whether positive or negative, are potentially legitimized through popular culture's presentations. Moreover, the results of this study also show that students are unaware of the processes and proficiencies of mathematical learning. More specifically, teachers and others must help students understand knowledge is not transmitted by copying notes or that teaching strategies need to account for students being apprehensive to ask questions in a mathematics classroom. Memes can also be used to explore mathematics content, through error analysis and explanation of concepts.

DEDICATION

Though I’m the sole author of this dissertation, there are a lot of people who have invested in me and my work over the last five years to make sure it has come to fruition. I would like to thank my father; though our time was brief, you lit a fire in me that grew into the love of mathematics. I would like to thank my five beautiful sisters for raising me and each having their own unique way of teaching me life lessons. I would like to thank my friends; though we never made an official pact, your success in various fields has helped fuel my ambition to pursue new heights. To my aunt / cousin Guilaine, thank you. Words cannot express what you have done for me; you gave me so much and asked for nothing in return. You are the true definition of what it means to be selfless. To my mother, thank you for being the hero I needed. Knowing what you overcame to give us a better life has truly inspired me never to settle for less. And to my future wife, Jennifer Ann, thank you for forever being in my corner. Thank you for keeping me grounded and humble and focused on what truly matters. ~BARS~

To future generations of the Dailey, Sajous, Evariste, Bernardeau, Benoit family, this dissertation is for you. Use this as a catalyst to show that no matter what your circumstance is, overcome your obstacles and reach for your dreams.

ACKNOWLEDGMENTS

I would first like to thank my advisor, Erica Walker, for encouraging me to pursue mathematics and popular culture as a research topic. Your support and guidance has been instrumental throughout this whole process. I would like to thank J. Philip Smith for having the uncanny ability to teach and reach his objectives in an unscripted manner. Thank you to Haeny Yoon for your genuine interest in my research and providing me with new perspectives. Dr. Felicia Mensah, thank you for “adopting” me as an advisee early in my doctoral career. I am extremely grateful for the time you have dedicated in helping me become a better writer and scholar. I would like to thank the Center for the Professional Education of Teachers (CPET) for becoming my family away from home. Lastly, I acknowledge my secondary researcher, dissertation writing partner, and brother Gàbor Salopek. It has been one hell of a journey with all the twists and turns, but I would not change one second of it. Köszönöm testvér.

G. B.

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Chapter I

INTRODUCTION

Dawkins (1989) states that memes are “an idea, behavior, or style that spreads from person to person within a culture” (p. 192). While the word “meme” was coined before the 21st century, Internet users have redefined it to describe a virtual phenomenon (Gal, Shifman, & Kampf, 2015). Internet memes can be in the form of an image, video, or file that virally spreads from one person to another via the Internet (Gross, 2010). A meme acts as a vehicle, carrying ideas, practices, culture, and/or symbols from person to person in various forms, including social media (e.g., Facebook, etc.). A growing body of academic research (e.g., Burgess, 2008; Knobel & Lankshear, 2007; Milner, 2012) aspires to decipher the social and cultural qualities of Internet memes and their implications. The fluidity of memes on the Internet and social media allows them to be produced as well as consumed by the general population and in turn has transformed them into popular culture (Black, 2006), a “domain that constitutes the intersection of individual cultures” (Fiske & Hartley, 2003, p. xviii).

With the advancements in technology, previous definitions of popular culture that included modes of transmission such as television, radio, newspapers, magazines, and so forth have become dated. Ellul and Merton (1964) state that technology is the dominating feature of contemporary civilization and will lead to massive physical, mental, and social changes. Popular culture has become pervasive; it saturates social media and aspects of our social and private life (Jeacle, 2017). Martin (2012) states that “social media such as

YouTube and Facebook are not only responsible for exporting and importing culture, ideology, protest, and revolution, but also for exposing the human condition" (p. 51).

Social media provides a platform where memes, such as Figure 1.1 and Figure 1.2, can impose their messages. The speed and scope of the Internet allow memes to be propelled through society at a fast rate, making them not only culturally relevant but also influential and impossible to ignore (Reich, 1992). "Memes harness the participatory potential of the Internet and typify modern popular culture" (Marwick, 2013, p. 13). With the click of a button, a meme can be disseminated to millions in seconds.

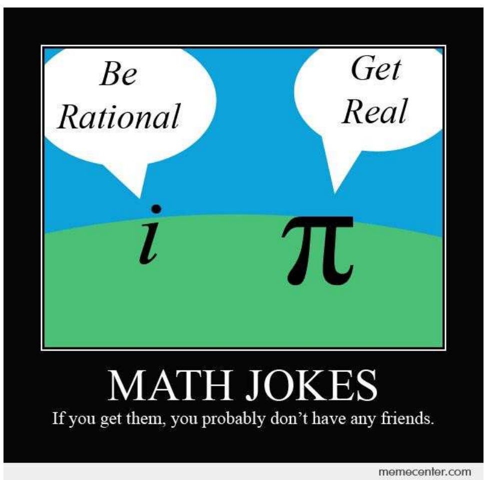

Figure 1.1. No Friends Math Meme

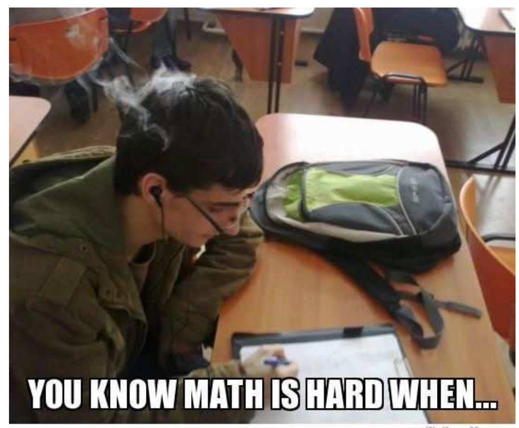

Figure 1.2. Math is Hard Math Meme

Some researchers have argued that society shapes and interprets thoughts and actions in stereotypical ways (Halpern, 2000). So what does society say about mathematics? The ideology of mathematics being hard, uninteresting, and accessible to only nerds still persists, even though the idea has been disproved by research (Boaler, 2000; Boaler & Greeno, 2000). Such negative views of mathematics make it seem socially acceptable to be "bad" in mathematics.

Based on existing memes (there appear to be fairly common messages depicted about mathematics in popular culture), I began to wonder if these generated representations and messages affect how students form their mathematics identity—an individual's beliefs about mathematics as a whole (i.e., reading, listening, doing, thinking, learning, retaining, etc.). Op't Eynde, De Corte, and Verschaffel (2002) state:

> Students' mathematics related beliefs are the implicitly or explicitly held subjective conceptions students hold to be true about mathematics education, about themselves as mathematicians, and about the mathematics class context. These beliefs determine in close interaction with each other and with students' prior knowledge their mathematical learning and problem solving in class. (p. 27)

Subsequently, I considered my former and present students' mathematics beliefs and how society's representations of mathematics might have influenced and/or are still currently influencing them. I questioned whether or not students' experiences were unique or whether there were common beliefs among all students. I became interested in learning more about why students developed their beliefs about mathematics and if stereotypes of mathematics perpetuated through representations in memes had any effect on them.

Despite calls from Giroux (1994) and McLaren (1995b) to pay more attention to popular culture for its influence and power, it remains one of the most understudied areas in academia (Apple, 1996; Martin, 2012). The inaugural analysis of popular culture seems to belong to other disciplines (Appelbaum, 1995), as several studies have been completed on the effects of popular culture in Science, History, and English. Little work, if any, has "been done by math educators to probe the efficacy of mass culture criticism for education in math" (Appelbaum, 1995, p. 24). For better or worse, popular culture is playing an increasingly important role in the lives of our youth, and discourse is needed because schoolteachers are not the only ones delivering messages to students; media is a powerful complement (Condry, Bence, & Scheibe, 1988; Frymer, Carlin, & Broughton, 2011).

We may have to go beyond the conventional definition of mathematics as a subject and delve deeper into students' beliefs about mathematics, including how they see themselves from a mathematical lens (Martin, 2000). Sfard and Prusak (2005) stated that identity—how individuals see themselves based on their perceptions, based on everyday life experiences—could be the missing link in education. According to Erikson (1968), forming and shaping one's identity is one of the most difficult tasks any adolescent will face, and it can be extremely difficult to form a positive mathematics identity when negative images or pervasive thoughts of mathematics are portrayed in popular culture. Rimer (2008) asks what effect popular culture has on students' mathematics identities, especially considering that mathematics already has a stigma of being a difficult subject.

In order to investigate popular culture's effect on students' mathematics identities, Appelbaum (1995) suggests an analysis of how mathematics is viewed on "TV shows of the popular variety" (p. 33). To incorporate the technological shift of the 21st century, I would like to further that analysis and include how mathematics is portrayed in memes.

The youth today have grown up with television, movies, music, and videogames, and without discernment are susceptible to the conveyed messages in popular culture (Fiske, 1989; Kumar, 1997; Luke, 1997). As media continuously produces representations and imagery of mathematics for "imagining or transgressing life experiences," it is essential to encourage and inspire students to reflect on those representations (Alvermann, Moon, & Hargood, 1999, p. 141). If students internalize these messages, there is no designed space to confront and combat these messages, leaving them to manifest and evolve, influencing and damaging students' mathematics identity.

> Such educational encounters also necessitate reflection on identity and individuality, as that analysis of popular culture insists that one consider the reason why he or she finds a particular TV show, film, magazine, or whatever something that he or she enjoys or has some use for. (Appelbaum, 1995, p. 25)

Purpose and Research Questions

This dissertation builds on the research of Reyes and Stanic (1988), Appelbaum (1995), Martin (2003, 2010, 2012), Alvermann et al. (1999), and Marshall and Sensoy (2011) and will investigate what messages students may be receiving about mathematics from popular culture, specifically memes. In conjunction, this study will also explore whether these messages are being internalized by students and are affecting their mathematics identities. At the heart of my research lie the questions:

1. What messages, if any, are students receiving about mathematics from memes in popular culture?
2. If messages about mathematics from memes in popular culture are received by students, how are they internalized?
3. How are associated messages from memes influencing the construction of mathematics identity?

Research Approach

No matter the method (quantitative or qualitative), identity is an extremely difficult topic to research (Klein, 1982; Plucker, Beghetto, & Dow 2004). Creswell (2007) suggested that a qualitative research approach could be utilized to best explain a complex study and provide detailed understandings. Marshall and Rossman (2006) and Merriam (2002) both concluded that qualitative research methods provide a broader approach for a complex contemporary study and should help gain in-depth understanding about how students describe their perspective. However, Johnson and Onwuegbuzie (2004) state that qualitative research allows you to test and validate findings as they occur; therefore, a mixed modeling approach was employed. Mixed modeling, not to be confused with mixed methods, entails that both qualitative and quantitative approaches are used across different stages of the research process, but were not necessarily all stages (Johnson & Onwuegbuzie, 2004).

For the qualitative aspect of the research, several forms could have been utilized. For example, Reyes and Stanic (1988) stated that they elected to use an ethnographic approach for their research (i.e., interviews) because it would be fruitful and a better way to understand what is being described. A secondary researcher, Gabor Salopek, and I support both suggestions and believe richer and more meaningful data can be elicited through the interviewees' thoughts and articulations, but some statistical analysis could help validate and explain matters further, Therefore, to investigate this complex issue, a two-tiered approach (a focus group and an individual meme activity) was used. A focus group with a semi-structured questioning approach was selected because focus groups are effective for capturing a variety of opinions within a social context (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). An individual Internet meme activity was also selected to offer an individual perspective (emotions, non-verbal cues, etc.) without the social context. For the purpose of this research, both were used to examine the effects of messages found in popular culture about mathematics, specifically mathematics memes, on individuals' mathematics identities.

Settings and Participants

The study targeted high school students between the ages of 13 and 18 years and consisted of 5 focus groups and 31 student participants. Researchers gave a short informative presentation to selected classrooms from my professional network of current or past Teachers College students located in New York. The presentation informed potential participants of the research's purpose and their explicit involvement. The presentation also contained a short promotional YouTube clip created by the principal researcher and secondary researcher, Gabor Salopek, who is conducting a separate study investigating what messages students may receive about mathematics from video clips found in popular culture. The YouTube clip served as a recruitment tool for both studies (see Appendix A). Upon completion of the presentation, students were told that participating in the study would in no way, shape, or form affect their grades in any of their classes. Other potential participants were recruited by flyers (see Appendix B) in their respective schools, school announcements, teacher selection, and individual recruitment.

Student assent (see Appendix C) and parental permission (see Appendix D) forms were distributed upon completion of the informative presentation to student participants that elected to volunteer. Both participant assent forms and parental consent forms were signed and returned in order to be considered for the selection group pool. Students were given complete discretion and could have opted out of the study. The 31 total student participants were selected to allow for the study to be reflective of the general population. Teachers from my professional network assisted by using purposeful sampling for the participant pool. Teachers balanced participants so that there would be equal distribution with regard to age, gender, and racial/ethnic identification. Selected participants were informed of the research's purpose, that their responses would be completely anonymous, and the potential impact their participation could have on future research. Participants also received a small token of appreciation, a pizza party, for giving up their free time to participate in the study.

Both the primary researcher and secondary researcher facilitated the interviews at the respective schools involved because participants were familiar with the location and there was an established sense of community and safety. Principals at the selected schools were contacted in advance to give permission by signing an approval form (see Appendix E) and reserve a location for interviews to be held. Even though they were not needed, students were also informed that under special circumstances, the study could be conducted outside the school's location with parental consent. Focus groups lasted approximately 60 minutes and were conducted outside instructional time. Dates of the focus group sessions were based on convenience, time availability, schedule, and proximity.

Data Collection Frameworks

There were a host of materials used during the creation of instruments to collect data but none more critical than Reyes and Stanic's (1988) framework, explained in the literature review. Reyes and Stanic's framework provided a conceptual map, which researchers were able to use to identify a specific focal area in the spectrum to analyze (i.e., societal influence on mathematics). Further, Hall's (1997) theories of representation framework were also consulted to determine the images selected for the Internet meme activity. Lastly, Guba's (1981) trustworthiness framework was utilized to ensure consistency throughout the instruments and dependability of the questions and tasks students were being asked to do.

Focus Groups

During the focus groups, some aspects of phenomenology were used because I sought to explore students' perceptions, internalizations, and identities across different experiences. Student participants were placed into focus groups based on their respective schools, with no more than seven participants from each school. The teachers of those respective schools played a pivotal role in selecting the student participants. The teachers were told to design a focus group based on diversity because those of different genders, education, access to resources, etc. would have different viewpoints and group dynamics because participants influence each other through their presence.

As recommended by Mack et al. (2005) in *Qualitative Research Methods: A Data Collector's Field Guide*, focus groups were audiotaped with informed consent from each interviewee, and were professionally transcribed prior to data analysis. Coding revealed patterns and themes to bring meaning, order, and structure to the textual analysis. The focus group transcripts were used to answer research questions 1, 2, and 3.

Individual Internet Meme Activity (IMA)

As part of the research design, each student participated in an individual Internet meme activity (IMA). The individual section allowed participants a moment of silence and reflection. Most importantly, it allowed the researchers to home in and focus on the individual, so that thoughtful notes and meaningful follow-up questions could be asked. Students were presented nine mathematical referenced memes (see Appendix F) selected by a jury of mathematics professionals (i.e., teachers, doctoral students, professors). Upon jury deliberation, an equal amount of positive, neutral, and negative referenced memes were chosen to present to participants (three apiece). Student participants were asked to place the nine memes into one of three predetermined groups (positive, neutral, or negative) according to how they perceived the message or determined the relationship. Students then gave a short description of why they made the selections they did (i.e., for what made the memes positive, neutral, or negative, see Appendix G). The descriptions of the groups explicitly were connected to the message they had received. Students were in full control throughout the whole process and could portray whatever mathematical idea(s) they wished to. Moreover, students also talked about the exposure to each one of the groups they had described and whether or not the messages were valid or held merit to them. The Internet meme activity and follow-up questions were designed to shed light on research questions 1, 2, and 3.

Data Analysis

Through the analysis of responses, the study investigated if and how memes found in popular culture about mathematics influenced students' mathematics identity. The data collection plan was designed to gather data in multiple forms to address research questions 1, 2, and 3. All focus group data were transcribed for better accuracy and reliability of analysis. The grounded theory approach was utilized to systematically help the researchers examine all data and converge them into codes; codes were then converged into overarching themes. Responses were also analyzed with respect to grade, gender, and self-perceived mathematics ability (SPMA). The individual meme activity was analyzed in four ways: (1) participants' individual responses of positive, neutral, or negative were compared and contrasted against the responses of other participants; (2) participants' individual responses were combined to compare and contrast their coding of positive, neutral, or negative in respect to the jury selection; and lastly, (3) participants' written descriptions were analyzed and coded as well using the grounded theory method.

Positionality

Early in my doctoral career, I heard one of my professors give a talk about their interest and their scholarly work. The professor mentioned they were interested in gender difference in mathematics and how popular culture might help perpetuate stereotypes. The professor's short presentation resonated with me deeply. It brought out countless memories of being a high school mathematics teacher, and every so often I would hear students make statements like "It's OK to be bad at math" and leave random memes on my desk. I was aware of the representations of mathematics that existed in popular culture but was unaware that they were being reinforced by memes. It seemed as though memes were promoting stereotypical views of mathematics. Although some researchers might argue that memes and the media do not obstruct students, there is no outlet for processing the messages conveyed in popular culture texts (Fiske, 1989; Luke, 1997).

My thinking about the role of mathematics education has vastly changed and been redeveloped through my personal experiences as a teacher and course selection as a doctoral student. My position as a Black male public school graduate now studying and teaching mathematics education has been frustrating at times, but has opened my eyes to the ways representations might impact beliefs about mathematics. Media continues to produce negative images of mathematics; it is important as an educator in the 21st century not only to reflect on these images but to encourage our students do the same (Alvermann et al., 1999).

Chapter II

LITERATURE REVIEW

I begin this review by discussing the definition and importance of identity using two main researchers: Mead (1913/2011) and Erickson (1950). I mention the work of Sfard and Prusak (2005) and Gee (2000) to illustrate the educational importance identity serves. Within the spectrum of identity, I focus on one's mathematics identity and allude to the works of Martin (2003, 2009, 2012), Walker (2006, 2012), Anderson (2007), Boaler (2000), Alvermann et al. (1999), D'Ambrosio (1993), and others. The selected researchers collectively provide a robust definition and emphasize the importance of the development processes when creating a mathematics identity. I then refer to Gee's (2000) framework of multiple identities in relation to establishing a mathematics identity, where Gee discusses four common identities individuals navigate through (Nature-Identity, Institution-Identity, Discourse-Identity, and Affinity-Identity). In Gee's framework, I highlight the affinity perspective for this study because learning is a communal process, and in the 21st century, that process has and continues to change. Education has transcended past schools and is happening in various settings. Students spend approximately one-fourth (six hours) of their weekday in school and the rest, a majority of their time, absorbing information from outside of the institutional boundaries (Frymer et al., 2011).

Given students' level of exposure to popular culture, the potential impact has become a heightened interest in academia (Frymer et al., 2011). Therefore I use Stuart

Hall's (1997) theories of representation framework and Bernstein's (2000) media discourse to assist in analyzing media representations of mathematics. Though popular culture research is a relatively new focus in regard to mathematics education, I summarize the dialogue and literature of researchers such as Giroux (1997), Fiske (1989), Walker (2006, 2012), Appelbaum (1995), and others who have begun to venture down this path. Collectively, the scholarly pieces convey a similar message: mathematics is not shown in a favorable light in popular culture, which can be detrimental when trying to create a mathematics identity.

Previous academics have offered the definitions of popular culture and have used them in their works, but popular culture, too, has changed and continues to change daily. In the 21st century, the definition has matured and needs adjustment. Authors and researchers such as Marshall and Sensoy (2011), Schifman (2011), and Gal et al. (2015) have all noted that the progression of technology has affected popular culture tremendously. Utilizing their work, I have put an emphasis on how social media and Internet memes (a form of an image, video, or file that goes viral) have undoubtedly changed the definition of popular culture and affinity groups. My research incorporates the shift and uses an updated definition of popular culture to research the interaction between it and learners developing a mathematics identity.

Theoretical Considerations

Beliefs and Identity

What is known about beliefs and identity in terms of mathematics education? Although works on beliefs and identity can be found in areas as diverse areas of study, their place in teaching and learning mathematics is not as well-researched (Leder, Pehkonen, & Törner, 2002) as in other disciplines. McLeod (1992) similarly argued that research concerning the "affect in mathematics education continues to reside on the peripheral of the field" (p. 575). Despite a general agreement about how important students' identity and beliefs are, researchers in a variety of areas have come to see identity and beliefs as critical tools for understanding schools and society (Alvermann et al., 1999; Gee, 2000; Heath, 2003), which are important cross-sections in the daily life of a student. In today's world, students must know how to navigate to become active participants. The growing number of studies in this research area stand as a testament to the power of belief and identity (e.g., Berry, 2008; Diversity in Mathematics Education [DiME] Center for Learning and Teaching, 2007; Gutiérrez, 2008; Schoenfeld, 1985, 1992; Taylor, 2005; Walker, 2006; Weissglass, 2002).

The terms "identity" and "belief" take on different meanings depending on the context. Identity and belief are adjustable lenses; one can zoom in (Lerman, 2001) to the individual level and examine interactions or zoom out to look at the wider socio-political context (Stinson & Bullock, 2012). The lens is left to the researcher's discretion and is left to whichever level of the zoom provides an understanding of the situation (Stinson & Bullock, 2012).

To define identity, it is useful to examine two iconic figures of identity research. According to Erikson (1950), identity is a person's mental perception of who he or she is. His perspective on identity involved the notion of a core identity. According to Mead (1913/2011), "self" can take on new identities depending on the social context. Mead's perspective introduces a notion of multiple identities, which can sometimes be contradictory, and seem performative (Lerman, 2012). Essentially, Erikson understood identity as an acquisition, and Mead understood identity as an action (Darragh, 2016).

Holland and Lachicotte (2007) sums it up best:

> An Eriksonian "identity" is overarching. It weaves together an individual's answers to questions about who he or she is as a member of the cultural and social group(s) that make up his or her society. A Meadian identity, on the other hand, is a sense of oneself as a participant in the social roles and positions defined by a specific, historically constituted set of social activities. Meadian identities are understood to be multiple […] and they

> may reflect, for example, contradictory moral stances. Eriksonian approaches, in contrast, attribute psychodynamic significance to achieving a coherent and consistent identity that continues over the course of adulthood. (p. 104)

Despite these variations in defining identity, many researchers still state the concept as critical for making sense of students' mathematical achievement. Gee (2000) claims that identity is negotiable and is recognized by different factors. Cobb et al. (2009) define identity in a situation perspective and refer to Gee's (2000) social construction of identity, but with the addition of an internal decision. Similarly, Boaler and Greeno (2000), Martin (2000), and Stinson (2008) state that students draw from multiple experiences to construct a coherent description of themselves. Many researchers (e.g., Bishop, 2012; Esmonde, 2009; Holland, Lachicotte, Skinner, & Cain, 1998) agree and describe identity as shifting contingent on the situation. MacLure (1993) defines identity as "a resource that people use to explain, justify and make sense of themselves in relation to others, and to the world at large" (p. 311). Martin (2012), however, bridges the acquisition-action divide, defining identity as a set of beliefs (something that can be acquired) and also looking at identity in using mathematics to change the conditions of one's life. Further, Wortham (2006) explored how identities solidify over a trajectory of time, so an individual becomes more regulated in a specific way.

Research has shown that the challenges associated with defining self can impact one's understanding of their place in the world, especially during the pivotal teenage years, and have a significant impact on later life and how a person chooses to interact and interpret his or her world (Kinney, 1993; Sfard & Prusak, 2005; Weinstein, 1969). Richardson (1996) states that beliefs are "psychologically held understanding, premises, or propositions about the world that are felt to be true" (p. 103), meaning "beliefs are independent of their validity" (Scheffler, 1983, p. 129). Beliefs are an individual construct that arise from personal narrative but are not independent; they cannot exist without a social milieu (Heath, 2003). They are mental symbols and processes that we utilize to decipher and engage with the world (Heath, 2003). Oftentimes "beliefs are so deeply held that they affect the way which people process information and arrive at judgments" (McGrath, 2013, p. 83).

According to both definitions above, we are not born with beliefs or identities (Erikson, 1950; Heath, 2003). Our beliefs and identities are learned and become embedded. "They become habits of thought, feelings and behavior" (Heath, 2003, p. 1) depending on cultures we are exposed to, and as humans we are constantly "engaged in the negotiation of social relation and identity" (Apple, 1996, p. 130).

One of the basic mechanisms of our minds at a young age is to believe and accept what we see and hear (Gilbert, 1991). "We begin by believing everything; whatever is, this true" (Bain, 1886, p. 511). Later on, as functioning participants, we now begin to interrogate ideas and propositions that conflict with prior ideas and propositions and might consciously change our thoughts (Spinoza, Feldman, & Shirley, 1982). This conceptualization illustrates that beliefs are grounded in a socio-cultural environment and are a product of social life (Abreu, Bishop, & Pompeu, 1997). Both beliefs and identity serve as interpretive lenses to how we view the world, influence our choices, and provide us with a sense of evaluation (Philipp, 2007). However, neither identity nor beliefs are fixed; they shift in regard to the factors or experiences and are, in fact, transcendental (Shakespeare & Erickson, 2000).

Students' beliefs and identity have an important influence on mathematical learning (Leder et al., 2002). "The issue is how to put things together—how to see everything connected to an individual (both 'internally' in the sense of knowledge, identity, etc. and 'externally' in terms of that person's relationship to various communities) and the communities to which individual along as a coherent whole" (Schoenfeld, 2006, p. 500). Research has shown how students' beliefs about mathematics determine how to approach a problem (e.g., Garofalo, 1989; Schoenfeld, 1985), how students' mathematical related beliefs affect their motivational decisions (e.g., Kloosterman, 1996), and how students' beliefs related to mathematics education provided context to their emotional responses (e.g., McLeod, 1992). Leder et al. (2002) state, "Students' mathematics related beliefs are the implicitly or explicitly held subjective conceptions students hold to be true, that influence they mathematical learning and problem-solving" (p. 16). Moreover, this relationship between belief, identity, and influence seems to be reciprocal. This relationship "exert[s] a powerful influence on students' evaluations of their own ability, on their willingness to engage in mathematical task, and on their ultimate mathematical disposition" (National Council of Teachers of Mathematics [NCTM], 1989, p. 233).

Mathematics Socialization and Mathematics Identity

Students' mathematical beliefs and identities are not solely composed of their mathematical classroom experiences (Leder et al., 2002). As members of various groups, students bring various beliefs and identities with them that determine their unique construct (Pehkonen & Törner, 1996; Underhill, 1988). This conceptualization was later defined by Martin (2003) as mathematics socialization: "the experiences that individuals and groups have within a variety of mathematical contexts, including school and the workplace, and that legitimize or inhibit meaningful participation in mathematics" (p. 16). When discussing mathematics identity, it is important to recognize the impact of mathematics socialization (Resnick, 1987; Schoenfeld, 1992). Mathematics socialization takes the parents, the communities, the schools, the teachers, the different experiences, the social context, etc. into account and characterizes them all as active and critical pieces (Martin, 2000). A significant portion of students' mathematical socialization process happens within the classroom, where traditionally students work independently on single-answer problems with an emphasis placed on the right answer (Anderson, 2007; Boaler, 2000; Boaler & Greeno, 2000). That can be problematic because some mathematics classes have been, and continue to be, taught over-emphasizing procedural knowledge, leaving out the discussions of why, removing students from the center of learning, or having a voice in their learning (Boaler, 2000). Teachers may find it difficult to change their approach because of their own school experience, which was algebraic manipulations disguised as mathematics (Willis, 2010). In classrooms, students are learning more than just mathematical skills and concepts; they are also exploring and discovering who they are as mathematical learners (Anderson, 2007; Boaler, 2000; Boaler & Greeno, 2000). So the teaching style and learning structures used in mathematical classrooms need to foster and contribute to students' perceptions in their ability to understand and perform mathematics. The activities students engage in should help produce the learning environment rather than forcing participation (Saxe, Dawson, Fall, & Howard, 1996). The crux of this transformational process is to consider the experience that students are to develop, the knowledge that is to be learned, and the nature it is to be learned in (Davis, 1994). "In particular mathematics education should foster the development of socio-mathematical norms including the development of student autonomy in the ability to judge mathematical solutions on the basis of the differences, sophistication, efficiency and acceptability" (Teppo, 1998, p. 8). As students go through school, it is important that they learn who they are through a mathematical lens as they engage in a mathematics environment that promotes their identities as capable mathematics learners (Alvermann et al., 1999; Anderson, 2007; Boaler & Greeno, 2000; D'Ambrosio, 1993; McLeod, 1992) and pushes their thinking beyond just the classroom.

Though a number of dispositional factors that affect students' mathematical learning have been presented, often neglected is the idea of self-agency and self-efficacy that "operates within a broad network of socio-structural influences" (Bandura, 1997, p. 6). Bandura described self-efficacy as a "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 2). Later he stated:

> People's beliefs in their efficacy have diverse effects. Such beliefs influence the courses of action people choose to pursue, how much effort they put forth in given endeavors, how long they will persevere in the face of obstacles and failures, there resilience to adversity, whether their thought patterns are self hindering or self deating, how much stress and depression they experience in coping with taxing environmental demands, and that level of accomplishments they realize. (pp. 2-3)

Therefore, in this dissertation, I will use Martin's (2003) definition of mathematics identity:

> the beliefs that individuals and groups develop about their mathematical abilities, their perceived self-efficacy in mathematical contexts (that is, their beliefs about their ability to perform effectively in mathematical contexts and to use mathematics to solve problems in the contexts that impact their lives), and their motivation to pursue mathematics knowledge. (p. 16)

As a mathematics major, a teacher, an instructor, and a lifetime student, I think it is essential to study and acknowledge how students identify themselves mathematically and, more importantly, what influences that process. Schoenfeld (1992) states that there has been a fairly extensive amount of research on student beliefs and teachers' beliefs (respectively) and as yet relatively little exploration of what "general society believes about doing mathematics" (p. 358). Rock and Shaw (2000) suggested that gaining insight and changing students' perception about mathematicians may "facilitate and broaden children's thinking about their roles as future mathematicians" (p. 550). In addition, Schoenfeld (1992) asserted, "[We] understand little about the interactions among [beliefs, resources, problem-solving strategies, and practices] and less about how they come to cohere—in particular how an individual's learning fits together to give the individual a sense of the mathematical expertise" (p. 363). How can we or do we try to understand the intricate mix of students' mathematical exposure inside and outside of school and how it may contribute to inequities experienced by mathematical learners in our mathematical communities?

Researcher Wilbur Paul Gee's work has assisted in the advancement of using identity theory in the educational realm. Gee's (2000) framework emphasized the concept of multiple identities based on the notion that in specific societal environments, people assume different identities (see Table 2.1).

Table 2.1. Four Ways to View Identity

	Process	Power	Source of Power
Nature-Identity: A State	Developed From	Forces	In Nature
Institution-Identity: A Position	Authorized by	Authorities	Within Institutions
Discourse-Identity: An Individual Trait	Recognized in	The discourse/ dialogue	Of/with “rational” individuals
Affinity-Identity: An Experience	Shared in	The Practice	Of “affinity groups”

> Nature-Identity (a state) is the perspective that we are what we are primarily because of our “natures.” Institution-Identity (a position) is the perspective that we are what we are primarily because of the positions we occupy in society. Discourse-Identity (an individual trait) is the perspective that we are what we are primarily because of our individual accomplishments as others recognize them. Affinity-Identity (experiences) is the perspective that we are what we are because of the experiences we have had within certain sorts of “affinity groups.” (Gee, 2000, p. 100)

It is crucial to realize that individuals are positioned within multiple types of identities, needs, and lifestyles (Duncum, 1997), and these four perspectives are not separate from each other (Gee, 2000). The ways in which learners share and co-participate in them serve as some type of interpretive system underwriting the recognition of which identity is most applicable at the time (Taylor, 1994).

An affinity group is made up of people who share a common interest or bond, such as being members of an organization (Gee, 2000). Affinity perspectives are particularly important in regard to mathematics identity and memes because learning and knowledge are socially constructed (Leder et al., 2002; Scheffler, 1983; Thompson, 1992). The affinity perspective should also provide insights into how people acquire identity based on their affiliation to various groups (Erikson, 1950) and analyzing how individual mathematical experiences affect an individual's outlook on his or her affinity group and his or her mathematical identity. Learning mathematics does not just happen; learning mathematics is a social and cultural activity (Teppo, 1998) and requires participation. Knowledge is modified according to numerous factors and social situations (Rogoff, 1990). The learning an individual participates in takes place within multiple layers and settings (i.e., school, home, Internet, social interaction, etc.). In this way, identities are seen to be malleable and are consistently undergoing construction as a result of our relationship and participation with others (Wenger, 1998). So the affinity groups we belong to are intimately linked and may ultimately affect us.

Theories of Representation and Media Discourse

Furthermore, the recognition of identity as multi-layered has problematized the impact of the sophisticated forms of expressions made available by the evolution technology, especially in computer-based media (Garzone & Catenaccio, 2009). Therefore along with Gee's (2000) identity framework, I used a cohesive blend of Stuart Hall's (1997) theories of representation framework and media discourse (Bernstein, 2000). According to Hall (1997), the primary theoretical approaches that help us understand the concepts of representation are reflective, intentional, and constructionist approaches to representation. The reflective approach: "Meaning is thought to lie in the object, person, idea or event in the real world and language functions like a mirror, to reflect the true meaning as it already exists in the world" (p. 24). This theory explains that language emulates the true meaning of the object. The intentional approach: "Words mean what the author intends they should mean" (p. 25). This theory is in regard to the interpretation of an object but is contingent on the author's motive. The constructionist approach: "We must not confuse the material world, where things and people exist, and the symbolic practices and processes through which representation, meaning and language operate" (p. 25). Essentially this approach states that one constructs meaning through their our own meaning.

Bernstein (2000) states that media representations contain a range of discourses that may have a variety of discursive realizations. He emphasizes that media discourses are multi-layered, creating a variety of modes of communication, and are therefore complex as to their reception. Of importance is his view that cultural productions are the means by which power relations translate into discourse, and vice versa. The fact that media discourse is public signifies the importance with which we continually appraise the messages we consume because we cannot control the context, social relations, and motivations of the receivers or consumers (Evans, Morgan, & Tsatsaroni, 2006).

Popular Culture

Popular culture has evolved a great deal; it is portrayed through different media and connects the world to ideas, beliefs, and perspectives (Lipsitz, 1991; Walker, 2012). Stuart Hall (1986) affirmed that there is a connection between social forces and discourse—"the linkage may not be absolute and essential all the time" (p. 53)—but there is a connection. Popular culture is a social force that is permeating and is affecting discourse and, therefore, is culturally relevant when discussing identity (Ladson-Billings, 1994). D'Ambrosio (1993) explained that media (papers, magazines, radio, television, internet, etc.) exist outside school walls and are full ideas of mathematics that are "alive" (p. 46). Ultimately, it is the role of mathematics education to enable students to become aware of and access "alive" mathematics and develop "mathematical street smarts" (Davis, 1993, p. 192). Students draw meaning as they negotiate their way, and for this reason the portrayal of mathematics in any form of media demands our concern.

In their 1988 publication, *Race Sex, Socioeconomic Status and Mathematics*, Reyes and Stanic familiarized the idea that social influences such as communities, religious institutions, mass media, etc. affect students by sending implicit messages. The duo constructed and introduced a framework in hope of explaining differential achievements within mathematics. A single arrow within this model represents a one-way connection, while a double arrow represents a mutual connection (Duncan, 1975).

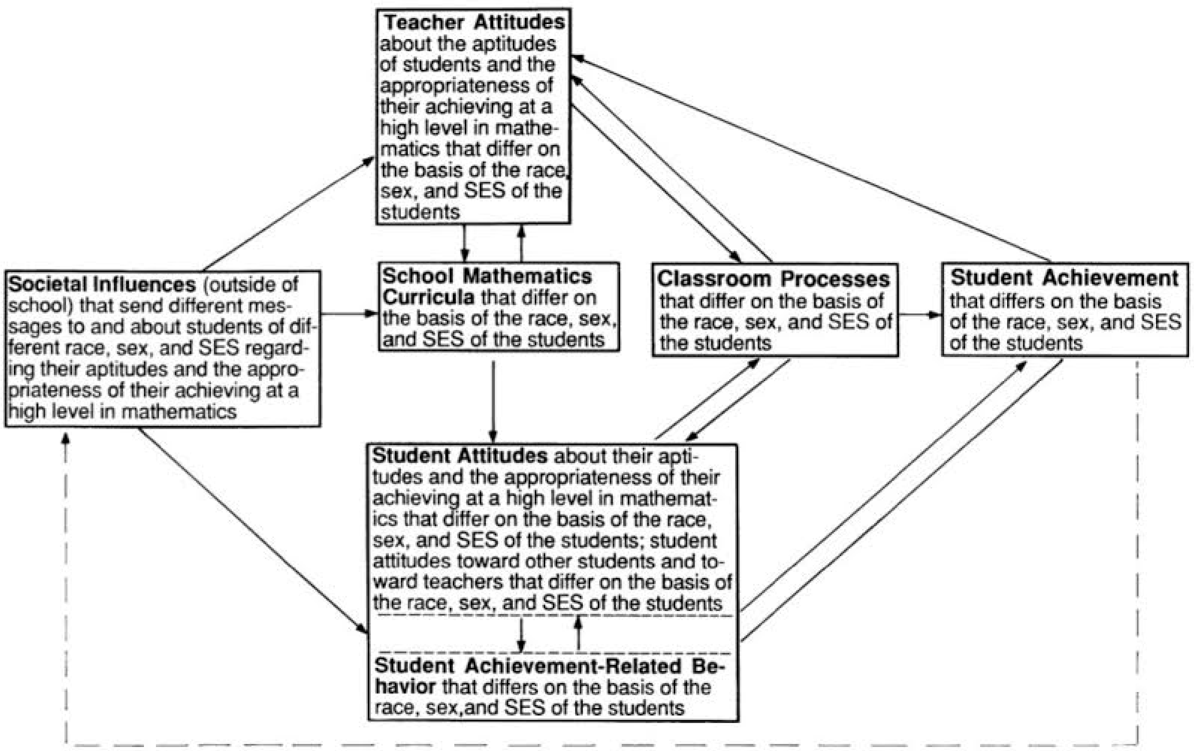

Figure 2.1. A model to explain difference in mathematics achievement. Source: Reyes & Stanic, 1988, p. 30.

Reyes and Stanic's (1988) proposed conceptual model begins with analyzing social influences outside the school setting that may send messages to students about mathematics. In this model, "Societal Influence" is hypothesized to have an association with "Teacher Attitudes," "School Mathematics Curricula," and "Student Attitudes and Achievement-Related Behavior," which in turn indirectly affect "Classroom Processes" and "Student Achievement." According to the conceptual model, teachers' attitudes indirectly affect student achievement through classroom processes, which is a theory that is backed by a large body of research (e.g., Ashton, 1984; Brophy & Good, 1974; Stronge, 2013; Walker, 2012). The model also shows that teacher attitudes have a reciprocal relationship with school mathematics curricula. Teachers' attitudes are posited to also have an indirect effect on student attitudes and student achievement-related behavior through mathematics curricula, which supports Fennema and Sherman's (1977) research on the connection between attitudes and achievement. This conceptual model holds classroom processes as the critical component. Reyes and Stanic (1988) state,

> Classroom processes serve as a mechanism through which teacher attitudes, student attitudes, and student achievement-related behavior can affect student achievement; similarly, teacher attitudes, student attitudes, and student achievement-related behavior may change as teachers and students interact in the classroom. (p. 38)

Though the framework of Reyes and Stanic's (1988) main objective was to provide a conceptual map for differential mathematics achievement based on race, sex, and SES, it also provides a framework that is closely aligned with the purpose of this dissertation. The framework and article precisely identifies societal influences (i.e., mass media) as a crux to implicit messages students may be receiving about mathematics. However, I will focus only on the connection of societal influence (i.e., popular culture, and more specifically memes) and students' mathematics identity without any special regard to sex, SES, or race.

The fact of the matter is that in 1988, Reyes and Stanic deliberately chose to discuss societal factors in regard to mathematics achievement. In 1988, they felt it was critical to explain to what extent teachers and students were accepting and/or resisting societal ideas. "More specifically, we do not yet fully understand how these ideas affect the teaching and learning of mathematics" (p. 3). Reyes and Stanic further stated:

> In the field of mathematics education, there is little, if any, research documentation of the effect of societal influences on other factors in the model [Figure 2.1]. Documenting these connections is both the most difficult and the most necessary direction for future research on differential achievement in mathematics education. (p. 33)

In 2016, still much is unknown; granted societal influences have changed, but those existing are powerful and persistent influences (Apple, 2004) and necessitate concern. Giroux (2002) argues that elements in popular culture enable conversations that connect "politics, personal experiences, and public life to larger issues" (p. 7). This particular argument suggests that popular culture should be examined for pedagogical concerns. Popular culture is public dialogue, and acknowledging its educational presence requires researchers and educators alike to find ways to blend the political and the pedagogical to inform the public (Cobb, 1997; Davis, 1992; Giroux, 2002) and increase the ability to understand how it is being internalized today.

Peter Appelbaum (1995) was primarily concerned with the representation of mathematics in popular culture and how it would affect teaching and learning in schools. He concluded that popular media continues to produce negative attitudes toward mathematics by allowing socially unacceptable behavior to be considered as "normal" (i.e., I can't do math) and also implicitly by the context of what is displayed regularly.

Popular Culture: Definition

Theorists and researchers alike have found defining popular culture to be an extremely difficult proposition due to its trendy nature. Popular culture can become dated as quickly as it is produced, rendering its definition susceptible to constant revision (Fiske, 1995; Marshall & Sensoy, 2011). The task of understanding popular culture becomes even more difficult because today's generation will have a different perspective on popular culture than the previous generation. As Fishwick (2002) stated, the operative term while defining popular culture is "new": new age, new generation, new definition. Adults often dismiss children's perspectives, but in popular culture pedagogy, it is the students who are the experts because of their more immediate and direct experience (Appelbaum, 1995).

The term "popular culture" in Fiske's (1989) definition refers to the unlimited source of commodities produced and consumed in the process of culture operating on a number of levels. Appelbaum's (1995) definition stated, "Media incorporate[s] all artifacts of popular culture. This includes television, video games, films, radio, music, newspapers, magazines" (p. 75). In 1997, Stuart Hall referred to popular culture as "widely distributed forms of popular music, publishing, art, design and literature or the activities of leisure-time and entertainment, which make up the everyday live of the majority of 'ordinary people'" (p. 2). Morrell (2002) defined popular culture as "a terrain of ideological struggle expressed through music, film, mass media artifacts, language, customs, and values" (p. 73).

An underlying theme in the definitions of Fiske (1989), Hall (1997), Morrell (2002), and Appelbaum (1995) is that popular culture "constitute[s] a gigantic empirical archive of human sense-making, therefore the taking, twenty-four/seven" (Fiske & Hartley, 2003, p. xviii). All definitions are complementary to one another and signify that popular culture is the entirety of perspectives, images, and other phenomena that are widespread in a shared culture and is synonymous with consumer culture, which is produced by the media for mass consumption. Therefore, in this dissertation, popular culture is interchangeable with mass culture, media, popular media, and reference communication by publication.

With the advancements in technology, today's most efficient way of mass communication is the Internet. The interface of the Internet allows users the power not only to engage in exploration that will affirm or transform their thinking (Fiske, 1989; Storey, 2006) but also to become creators themselves (Giroux, 1997; Lipsitz, 1994; McLaren, 1995a, 1995b; Storey, 1998). Therefore, with the inclusion of the Internet comes an adjustment to how we view and define popular culture. Preceding generations may have agreed with the definitions previously mentioned referring to newspapers, magazines, and books, but today's generation utilizes an assortment of media sources, including online networking systems (i.e., social media) such as Twitter, Facebook, and YouTube. Marshall and Sensoy (2011) proclaimed that social media offers snapshots that document life and its popularity continues to grow, with roughly two of three people in America having an account (Holcomb, Gottfried, & Mitchell, 2014).

Social Media Etiquette

Social media behaviors on platforms such as Facebook fall into three levels: consuming (liking), contributing (commenting), and creating (sharing and/or creating) (Muntinga, Moorman, & Smit, 2011, pp. 15-17). A "like," according to Facebook, is defined as "a way to give positive feedback or to connect with things you care about." A "like is a quick, effortless way to publicly show solidarity around an idea or aspect. A like is considered a consuming behavior, which is the lowest behavior in social media practice (Kim & Yang, 2017). It involves little action from participants and includes behaviors such as reading and watching. Commenting on a post or sharing a post is a practice that takes more commitment and effort. Commenting on a post is considered to be contributing behavior because it creates interactions between users within the lens of the contents (Kim & Yang, 2017). Commenting connects one another to a specific idea or entity and facilitates a semi-public conversation. Sharing and creating are at the highest level of social media behavior and involve producing and publishing content (Kim & Yang, 2017). Sharing a post illustrates content of value and drives further engagement. Creating and sharing are not arbitrary behaviors, but strategic behaviors in relation to self-presentation (Kim & Yang, 2017). Each social media behavior—"commenting," "liking," and "sharing"—is a known practice that builds social capital around a specific issue or proposition and needs a different amount of cognitive effort.

Memes

The prominence of the Internet and social media has led to an explosion of exposure for memes—forms of an image, video, or file that go viral—solidifying their eminence in popular culture and necessitating their addition to aforementioned definitions. Memes have become a sign of modern-day culture and a new cultural beacon for students. They are passed along from person to person using online communication and connect the world with ideas and perspectives (Knobel & Lankshear, 2007; Milner, 2012; Schifman, 2011). We now live in a world where we must not only acknowledge technology but continuously use it. The Internet gives the average user the power to create memes as well as distribute them (Knobel & Lankshear, 2007; Milner, 2012). The fluid nature of memes allows them to be both produced and consumed. Words and pictures separately send powerful messages, but memes offer a new form of expression, where meaning is made through both reading a caption and analyzing an image or video (Gal et al., 2015). The caption is reinforced by the image, and the image is reinforced by the caption, making that respective message not only clear and concise but also supported by multiple schemes.

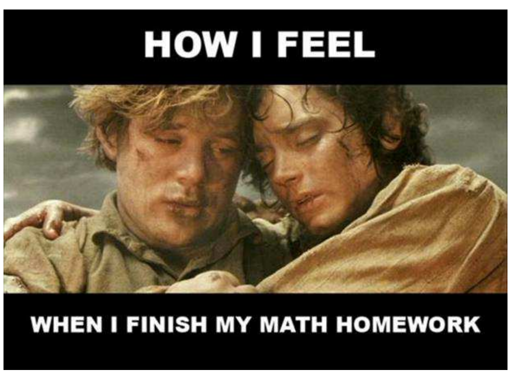

Figure 2.2. Mathematics Internet Meme

According to Hall's (1997) theory of representation framework, Internet memes have indications in two approaches: "intentional" and "constructionist." The "intentional" approach signifies the author's intention. Meme creation is not an arbitrary process; it requires a realization of compliance with its message or subversion (Butler, 1997). The organization, the arrangement of images, and words are not random; a great deal of contemplation goes into creating memes, such as those in Figures 2.2 and 2.3. Each selective choice reflects an idea or attitude from the creator's socio-demographic background and serves as a mirror into their interests (Duncum, 1997; Gal et al., 2015; Hall, 1997). The cultural production is a representation that both reflects and contributes to the construction media of discourse

(Evans et al., 2006). In this approach, the creators impose their ideology through memes, leaving little room for viewers to negotiate meaning for themselves. For example, in Figure 2.2, there are two men with looks of anguish on their faces after just escaping battle, and the caption reads, “How I feel when I finish my math homework.” Meaning is accessed through a shared language of the representation of battle.

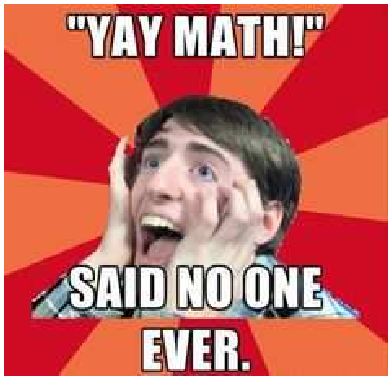

Figure 2.3. Mathematics Internet Meme

The “constructionist” approach helps us understand the cultural power of media by recognizing the images being witnessed and the social characteristics of language that give the objects a meaning. Hall (1997) states, “Things don’t mean, we construct meaning using representational system” (p.25). Meaning mobilizes feeling, and emotions only translate if we process images and captions the same way. For example, in Figure 2.3, “Yay Math!” seems to be a positive message but, paired with “said no one ever,” leaves a more neutral tone or “Yay Math! Said no one ever” can seem extremely sarcastic and have a negative connotation behind it. “It is worth emphasizing that there is no single correct answer to the question ‘what does this image mean’” (p. 9) and that interpretation is inevitable in this area.

So, in conclusion, the receiving of messages and meaning is not a passive state; the author’s meaning does not automatically project itself. Processing the meaning is just as significant a practice as trying to illustrate a meaning. Creating, commenting, liking, and reposting are complex expressions of negotiating social-cultural norms and to some degree serve as signs of affirmation with the memes’ interpreted purpose or message. Such significant roles play a major part in constructing and reproducing messages (Evans et al., 2006).

Mathematics in Popular Culture

Mathematics has the continual disadvantage of being characterized as challenging (Boaler, 2000; Moses & Cobb, 2001). Our societal emphasis on mathematics as a difficult subject has led mathematical underachievement to be taken negligibly (Vetter, 1994), hampering the growth of mathematically sufficient people. Students show a lack of interest in mathematics or a relatively higher tendency of mathematics avoidance, holding on to the belief that being good in mathematics is due more to ability than effort (McLeod, 1992). Many students admit this lack of achievement in mathematics as a permanent state over which they have little control.

Popular culture not only depicts strong sentiments toward mathematics as a subject but also toward the individuals who excel at it (Appelbaum, 1995). Though there are not a vast amount of examples when analyzing popular movies, TV shows, clips, etc. where the protagonist is a “mathematics genius,” there are allusions to people doing mathematics. Of the ones shown, few messages tend to be positive; however, they all seem to have similar characteristics (e.g., *A Beautiful Mind*—John Nash; *Family Matters*—Steve Urkel, etc.).

Socially Awkward Stereotype

Media consistently portrays an individual who is good at mathematics as shy, unattractive, or a social outcast (Boaler & Greeno, 2000; Kinney, 1993; Walker, 2012). The character is usually arrogant or a loner with a unique dressing style that gets ridiculed and rejected by their peers. For example, *A Beautiful Mind* (2001), tells the story of John Nash, who lived much of his life with paranoid schizophrenia. Even though Nash won a Nobel Prize, the film highlights his mental illness and portrays his cockiness and social ineptitude, which created animosity among his classmates. Or we can examine *Proof* (2005), where the first scene epitomizes Catherine’s life as she sits by herself. Or perhaps we look at Robert, her father, also a brilliant mathematician, but one who is suffering from delusions and schizophrenia. One detects intrinsic themes that mathematically sufficient people are individuals with a “thread of madness combined with a secret language of mathematics” (Epstein, Mendick, & Moreau, 2010, p. 49) and that genius equals madness. Though both characters in *Proof* were intelligent, neither emulated something that young viewers would strive for (Wilson & Latterell, 2001). Alex Kasman (2002) wrote, “There is a danger that many audience members who have little experience with real mathematicians will confuse the attempt to present schizophrenia with an attempt to present ‘the mind of a mathematician’” (p. 646).

When analyzing *Mean Girls* (2004), though, the converse is true. The main character, Cady, is a beautiful girl with no social flaws who is good at mathematics. But Cady plays “dumb” and neglects her competency at mathematics to make friends because mathematics is seen as a hard, obscure subject where only “nerds” do well. So rather than excel in mathematics class, Cady purposely does badly to be “cool.” Although Cady may have done poorly in her mathematics class, Philip Jackson (1986) would say she excelled in the *hidden curriculum.* Jackson stated that, along with academics, students also need to master a curriculum that is based on social interaction and power dynamics within a school’s context.

Math Gene Stereotype

The fallacious mathematics gene theory—certain individuals have an innate skill at mathematics—is still prevalent today in popular culture. A common implicit illustration of the this stereotype is when we see a “mathematician” doing some challenging problem with a notable lack of effort. In *Good Will Hunting* (1997), Will’s mathematics ability is instantaneous. In a matter of minutes, Will solves a difficult problem that is expected to take MIT graduate students a semester to finish. The professor, throughout the movie, continues to post difficult problems, and Will continues to solve them effortlessly—no pencil, no calculator, no notes, just Will at the board. Later, there is even a scene where

Will throws his test back at the instructor, complaining that it is too easy. The math gene theory also surfaces in *A Beautiful Mind:* Nash refuses to go to class, claiming that listening to math lectures is unproductive. Paul Ernest (1995) sums it up by stating, “A widespread public image of mathematics is that it is difficult, cold, abstract, … [and] has the image of being remote and inaccessible to all but a few super-intelligent beings with ‘mathematical minds’” (p. 1).

The math gene theory itself is detrimental, but to make matters worse, it gives rise to and supports other related ideologies about mathematics (Kimball & Smith, 2013). One extension from math gene theory came the idea of speed: to be considered good at mathematics, you have to do math fast (Mendick, 2005). While scenes in *Good Will Hunting*, *A Beautiful Mind*, and other movies demonstrate the notion of a math gene, they also illustrate the speed component. Each example contains snapshots that exemplify most depictions of a “math genius”: the mathematical task is done in a relatively quick manner with no mistakes (Kimball & Smith, 2013).

Another extension of the math gene is the perception of math child prodigies: to be a “math person,” you have to do sophisticated mathematics at an early age (Cox, 2000). Fictional childhood prodigies abound in literature (Harry Potter) and films (for example, *Iron Man* (2008), in which Tony Stark built his first circuit board at age 6 and graduated summa cum laude from MIT at 17. There are also characters in television shows, such as Stewie Griffin in *Family Guy*, T.J. Henderson in *Smart Guy*, or even Jimmy Neutron in *Jimmy Neutron: Boy Genius*. Math childhood prodigies do exist, but not to the extent that they are portrayed in the media.

Another derivative of the math gene concept is that to be a “math” person, you have to be great in every field of mathematics (i.e., statistics, topology, etc.). The caliber notion is also implicitly exhibited throughout the media. Mathematics is often portrayed as a mathematician ignoring books and conventional formulas but managing to devise a breathtakingly original solution that astounds and confounds all experts. Or it could be depicted as the cliché of expansive chalkboards filled with a variety of complex-looking equations and graphs.

The paradox is that these representations are wildly inaccurate and contradict the "typical" mathematician and his or her experiences in the world of modern mathematics. The "average" mathematician spends time attending classes, going to conferences, and working as a team member. Most ironic is that when mathematics is illustrated, it is usually incomprehensible nonsense—incoherent equations and multiple incoherent conversations where key words are thrown in to complete an illusion. The underlying message is that mathematical minds see things in a different way, and if you do not understand or if you do not see math in a different way, then, by definition, you are not a "math person." It is a clear signifier that everyone is not supposed to get it, just the "math people."

Nevertheless, not all messages about mathematics found in popular culture are outwardly destructive. There is a common message pertaining to effort and success that can also be seen. As it stands, it is a respectable message; however, when illustrated in popular culture, this message tends to be heavily exaggerated, such as a student finally agreeing to "buckle down" and study for his/her mathematics exam. The student is often flipping through multiple textbooks and notes, cramming as much as possible before the test, and is usually paired with a successful ending as the student passes the exam. In real life, this spontaneous effort does not always lead to achievement; in fact, this common nostalgic message can be harmful. Assuming that hard work will lead to success, students may feel a sense of displacement and lack of self-value when it does not (Riegle-Crumb, 2006). Students may implicitly attribute success to innate factors (which are beyond their control) rather than effort or education (which can be controlled), and may lead to wasted potential (Dweck, 2006).

In their studies of undergraduate students, Epstein et al. (2010) found that mathematics students tended to view mathematics as something that "permeate[s] the world" (p. 58), as opposed to non- mathematics students, who saw mathematics as just numbers. This study speaks to a larger problem and exemplifies a global dilemma; there is not a clear understanding of what it means to be good at mathematics or what it means to be a mathematician. But it seems as though media and popular culture have formulated a clear definition because negative portrayals of mathematics (e.g., It is not cool to be smart in mathematics) are highly salient. Media is said to influence everything it touches, and mathematics is no exception (Lumby, 1997).

Entman (1989) investigated how media affects what people think and discovered that participants' attitudes toward unfamiliar subjects were susceptible to media influence. Entman believed that the media influences "public opinion by providing much of the information people think about and by shaping how they think about it" (p. 361). Moreover, Alvermann et al. (1999) explained that people form their ideas through a mix of prior experiences and personal conviction concerning the stories and pictures portrayed in the media.

Popular culture offers a range of messages about mathematics, but the predicament becomes the imposed meaning and implications left by these images and underlying messages. "The meaning of self is established and assessed in terms of the meanings of the performances generated by that self within the culture" (Martin, 2003, p. 85), and in mathematics several labels that we place on ourselves as learners shape the way we view ourselves. Our students today are constructing their interest and attitudes through the projections of portrayed characters and messages. Mathematics does not have the luxury of being portrayed in a fantasizing fictional plot, so every message being portrayed serves as reality to some and is perceived to be true. Jackson (2009) states, "Mathematics instruction is not a social or cultural neutral process, [but] rather, is laden with social and cultural norms, expectations, and practices" (p. 176). Our narrow interpretations may restrict potential students' identification process because being mathematically proficient means subverting one's identity (Boaler & Greeno, 2000). Our stereotypical views of mathematics leave little room for any other interpretation than messages such as: "math is hard," "only nerds are good at math," etc., but these representations do not provide "opportunities for all" to succeed (Appelbaum, 1995, p. 182).

Summary of Mathematics in Popular Culture

It is not surprising that young people's everyday rituals and routines have been altered by the huge developments in technology; with information at their fingertips, they are spending more and more time on their computers (Fishwick, 2002). It is virtually impossible to "protect" children from popular culture and the exposure to harmful messages that have the ability to factor strongly into one's perceptions (Walker, 2012). Using the Internet and social websites is a common activity of today's children and adolescents (O'Keeffe & Clarke-Pearson, 2011). Between blogs, social media websites, and phone use, it is impossible to control what our children see nowadays. "Such sites offer today's youth a portal for entertainment and communication and have grown exponentially in recent years" (p. 1). From place to place it is different, but no matter where we are from the experiences, the conversations and the images we see have an effect on us.

The intentional purpose of some media may not have been educational, but due to its extensive reach, power, and influence, writers and creators have to be more responsible. Continued use of common stereotypes surrounding the subject and the characters in it is capricious. Social media limits the capacity for self-regulation, and children and adolescents are susceptible to peer pressure as they navigate through it (O'Keeffe & Clarke-Pearson, 2011). These depictions are crucial, and discussion of what has and continues to be portrayed is an important conversation, especially during a period in which our country needs to raise more STEM majors.

These images do not send a positive message about mathematics to the younger audiences, where stereotypes seem to prevail (Epstein et al., 2010). We can either continue to accept these representations and continue to negotiate their meanings or we can oppose their ideas and offer inclusive alternative messages. Whatever the residue that is left in the minds of the audience, we must take the interpretation of representations into consideration. While certain attributes might form from individual learning at the micro- and macro- cultures, as educators, we must at least be aware of the underlying residue stemming from the media and ask ourselves, “Was that acceptable?”

Affinity Groups from a Meme Approach

In 2001, Albert Bandura recognized the significance of “understanding the psychosocial mechanisms through which symbolic communication influences human thought, affect, and action” (p. 265). Examining mass communication from a social cognitive perspective, he analyzed how online communication systems operate from a socially mediated standpoint and explained that social influences are too complex to fall into easily understood patterns. However, he claimed that the media could implant and influence ideas as well as foster connections to social networks and community (i.e., the aforementioned affinity groups).

Social networking sites are “a form of online community through which users can connect with the people within and beyond this social circle” (Chen, Lu, Chau, & Gupta, 2014, p. 214). The integration of social media into our daily lives has impacted both online and offline interpersonal communication (Quan-Hasse, 2008). The media and Internet have undoubtedly redefined affinity groups; they are no longer solely defined by geography or class. People today can find ways to communicate with those like themselves and feel a stronger sense of community with those geographically farther away (Coder, 1996; Reich, 1992). Affinity groups today are rather defined by associations through the groups’ culture and/or communication, possibly facilitated through social media. The group needs to be committed to and participate in specific practices that create a distinctive identity for participants, and in return members are provided social support (Bandura, 1997; Gee, 2000; Hall, 1997). Members share a common language and common codes that enable them to make connections. To say that two people belong to the same affinity group means that they interpret a particular thing in the same way and will for the most part express themselves in a similar fashion (Hall, 1997). Therefore, the processes of power for affinity groups are generated through participation and sharing.

Let us examine the affinity group defined by those who say that they are “bad” at mathematics. This groups’ size is not fixed and members fluctuate in and out depending on their perspectives. Participants might think they are “bad” at mathematics because of distinctive experiences (e.g., difficulty understanding a class lesson, difficulty completing homework, failing tests). This group sees mathematics as a skill set that one possesses, not generates: either you know it or you do not; there is no figuring it out. This group has a fixed mindset and perceives qualities like intelligence or ability as fixed traits, believing that these talents alone, without effort, create success (Dweck, 2006). A fixed mindset in mathematics reinforces the prevalent view that people who are good at math have a special talent (Cirillo & Herbel-Eisenmann, 2011; Walker, 2012).

According to Stuart Hall (1997), members within an affinity group have similar “conceptual maps” pertaining to mathematics. Members make sense and interpret things in the same manner. There is no correction to negative depictions of mathematics; what is being depicted as real and what the affinity group thinks to be real do not differ. Such representation will not be rejected because it is partly formed by their appropriations of mathematics and popular culture. Individuals of this affinity group are obedient to their stance (dislike of mathematics); and though it might not be orchestrated, they create, like, share and/or comments on negative representation via a social platform, reproducing a dominant power (Evans et al., 2006), affecting individuals in many social contexts. The saturation of negative messages as a collective helps legitimatize and normalize their ideologies.

What is actually discerning is that those experiences of struggling are not necessarily unique or opposite of a “good” mathematics student. Everyone experiences difficulty at some point along the road. Struggling does not imply individuals as bad mathematics students (Dweck, 2006); it is part of the process. But students with fixed mindsets have an overall paradigm about knowledge and about how the knowledge is acquired that is central to a lot of other beliefs (Dweck, 2006; Leder, 1992; Teppo, 1998) and is strongly held. “Because of the differences in their fundamental beliefs, it is not easy to move them” (Teppo, 1998) especially when it will also affect other beliefs. Carter and Yackel (1989) compared changing belief systems to a paradigm shift in which it would be extremely difficult when the driving force behind the change might not be known in that knowledge system.

Due our society’s perception of mathematics, negative mathematics memes are easy to find and easily replicable, with numerous people creating new versions, which are, sad to say, socially acceptable. Hall (1980) states that there are preeminent forces and intended messages in culture. The creation and distribution of negative mathematics memes to the “bad”-at-mathematics affinity group are thus twofold: memes both reflect their norms as well as constitute and promote their central practice (Shifman, 2014). These memes gain influence through online transmission on social media sites and spread person to person like an “idea virus” promoting harmful messages (Marwick, 2013). It is sure to be troublesome when representations of “being bad at mathematics is OK” are displayed throughout memes in popular culture at exponential rates.

Memes are often referred to as just a joke, but these negotiations adolescents encounter online on a daily basis factor strongly into their perceptions of themselves and others. Today’s generation of children have grown up fully submerged in the digitalized age and live with the increasingly demanding world that requires participation and citizenship via online platforms, which entail increase their vulnerability (Marshall & Sensoy, 2011). Imagine an individual having difficulty with mathematics while simultaneously getting bombarded with the portrayal of negative mathematical memes. These memes describe strong sentiments about mathematics and subconsciously play a big role in society's view about mathematics. They not only emphasize that mathematics is difficult, but the fact that it is normal *not to get it*, suggesting that it is okay to give up on trying to understand it. "Popular culture shapes and reflects the belief of society and these depictions speak volumes" (Walker, 2012, p. 7). The beliefs that adolescents and their affinity groups possess about mathematics have been classified to impede the formation of "good" identities, which in turn affect their performance (Leder et al., 2002).

Study Rationale

This dissertation takes a modern day extension of Vygotsky's (1978, 1986) original works on the influence of a social context on an individual's development. The "wholeness approach" (Hedegaard & Fleer, 2013) was offered by Vygotsky (1986) with the explanatory metaphor of a molecule of water. Vygotsky indicated that examining the components—hydrogen and oxygen—separately would not yield accurate understandings of the whole, in this case, water. In terms of this dissertation, examining a high school student's mathematics identity without understanding insight into their mathematical experiences might yield wrong assumptions and false conclusions.

Popular culture's influence on mathematics identity is not the only factor affecting students' beliefs and performance in mathematics. Parents, family structure, environment, school, resources, teachers, other dispositional factors, etc. all play a fundamental role in a student's mathematical identity. Muller's (1998) study indicated that parental involvement factored into adolescents' mathematics achievement, and Keller's (2001) report affirmed that teachers influenced the achievement and/or beliefs of their students as well. Bandura (1986) stated that an often-neglected component, individual agency—students' resistance to what they considered to be negative influences—led to students' success.

Over the past several decades, popular culture has become a subject of heightened interest in academia. In order to better the mathematical practices and discipline structures of the 21st century, we must examine the confines of mathematical education and attempt to understand "how and why we should or could respond to its appearance" (Appelbaum, 1995, p. 25). If we are genuinely serious about increasing the number of mathematically proficient students, we must contest the common and popular negative mathematical depictions and recognize the effect they have on students.

A large portion of mathematics education research has tended to emphasize classroom activities, sequencing, and the execution of the lessons (Appelbaum, 1995), but to understand the mathematical development of students, we need to examine more than just strategies they do or do not demonstrate (Martin, 2010). Anne Teppo (1998) stated, "The goals of mathematics education research should reflect the diversity and complexity of its subjects" (p. 10). Schoenfeld (1992) additionally stated, "My own bias is that the key to this problem lies in the study of enculturation and socialization" (p. 363). Concerns need to shift to the sociocultural realm outside the classroom; we cannot ignore the effects of popular culture on mathematics identity, especially since "mathematics has become a critical filter for employment in our society" (NCTM, 1989, p. x). According to Tobias (2003), millions of adults are impeded from professional opportunities because they fear mathematics or have negative experiences that remain throughout their lives.

Prominent researchers such as Appelbaum, Martin, Leder, and Walker have discussed popular culture and mathematics. Such studies have incorporated notable sections from various sources and have acknowledged the association of social factors with mathematics identity. According to Leder (1992), "media plays an important role in shaping ideas and attitudes as well as reflecting and reinforcing popular beliefs" (p. 612). In order to change the societal perception of mathematics, Appelbaum (1995) calls for a change in how mathematics is viewed in mass culture, including "an analysis of TV shows of the popular variety, critical interrogations of popular music, and a close scrutiny of film" (p. 24). Op T'Eynde et al. (2002) mentioned, "Beliefs are grounded in the social contexts in which one functions" (p. 22). Several of the aforementioned studies of popular culture and mathematics have some limitations, which helped me shape and ultimately position my study. Studies failed to mention two phenomena—the Internet and memes; therefore, further investigation is needed. Research on the interaction of media influences, specifically memes and students' identities, is necessary and may lead to further insight on students' participation and performance in mathematics.

This dissertation takes a different perspective in analyzing popular culture and mathematics by investigating an array of mathematical memes in conjunction with student responses. Though analyzing mathematics and popular culture is not an unfamiliar study, it has never been examined through a memetic lens with so much precision. The overarching questions guiding this study are:

1. What messages, if any, are students receiving about mathematics from memes in popular culture?
2. If messages about mathematics from memes in popular culture are received by students, how are they internalized?
3. How are associated messages from memes influencing the construction of mathematics identity?

These questions are set to examine how youth are using, revising, and/or resisting mathematical memes found in popular culture.

Chapter III

METHODOLOGY

The purpose of my inquiry is to highlight and conceptualize what messages, if any, students are receiving about mathematics from Internet memes found in popular culture and how these messages maybe internalized. In this section, I will discuss the methodology used to increase our level of understanding about the connections between popular culture and mathematics.

Research Design

Before collecting data, I applied for approval to the Institutional Review Board (IRB) of Teachers College. My proposal was reviewed by the board to ensure that the research would proceed with appropriate protections against risk to humans (Marshall & Rossman, 2006), and since my research involved students under the age of 18, it was important that I gain informed consent and protected participants from any harm. Teachers College's IRB approved my proposal in April 2016, after which I pursued approval by the New York City Board of Education. Since my study took place in public schools in New York City, it required approval from their review board as well in order to conduct any research in the study schools. The New York City Department of Education review board granted approval of my study in July 2016. I began actively pursuing sites for my research during the start of school September 2016.

In this study, I focused on how mathematics identity might be influenced by the popular culture, specifically memes. Nowadays the qualitative/quantitative debate has advanced to the recognition of each paradigm offering its own different truths, its own different focus, and its own different complexities. But rather than focus on the ontological divide, this study sees the two paradigms as complementing one another. Both quantitative and qualitative approaches are important and useful; the goal is not to replace one approach but rather draw from their strengths while minimizing their weaknesses (Johnson & Onwuegbuzie, 2004). A number of quantitative researchers (Bond & Fox, 2007; Massof, 2008) suggest that the meaningfulness of a quantitative study lies in the data—how it is able to express consistently or invariantly the critical hierarchies of the central theme(s). Stake (1995) suggested that qualitative studies assist in seeking patterns of expected and unexpected relationships, and Hocevar (1981) additionally noted that a useful way to inquire about identity is simply to ask the subject. Nevertheless, both can be used to describe empirical observations. Sechrest and Sidana (1995) indicate that both paradigms "describe their data, construct explanatory arguments from their data, and speculate about why the outcomes they observed happened as they did" (p. 78). Therefore, I employed a mixed model approach, which incorporates a blend of qualitative and/or quantitative approaches in specific sections, not throughout the entire study (Sechrest & Sidana, 1995). As previously stated, my data collection structure was two-tiered. The focus group elicited meaningful data through interviewees' thoughts and articulations (Lincoln & Guba, 1985; Merriam, 2002), and an individual meme activity elicited data on participants' individual responses of positive, neutral, or negative mathematical memes to be compared amongst the jury and themselves.

The qualitative approach often utilizes subjectivity throughout the research process, and it was essential that as the researcher I reflected on the objectivity I brought to the study. As previously stated, I am a mathematics teacher, instructor, and lifetime student, and it is difficult to detach my voice, tone, attitudes, and feelings fully from this work. As a researcher, particularly one who utilizes some qualitative aspects, my role was very complex, especially in the beginning with identifying a meaningful topic. My experiences and personal perspective were initially conveyed when formulating research questions, developing a comprehensive research plan, and throughout the creative process.

Setting

The New York City Department of Education (NYDOE) is the largest school district in the US, serving millions of students in well over 5,000 schools of various types (public, charter, private, etc.). There are over 700 smaller districts, over 300 public charter schools, over 4,000 public schools, and over 2,000 private schools in New York City's five boroughs. The NYDOE is one of the most diverse public school systems in America, with nearly 40% of students in the city's public school system living in households where a language other than English is spoken.

Probing my New York professional network of current or past Teachers College students located in New York was a taxing task, but it proved to be extremely beneficial, because five teachers invited a secondary researcher, Gabor Salopek, and myself into their classrooms to give a short presentation to solicit student participants. Though restricted to my professional network, I wanted to explore high school sites all over New York City no matter the category (private, charter, public). My network did produce five high school teachers working in sites scattered across New York City (one in Queens, two in Manhattan, one in the Bronx, and one in Brooklyn) in a variety of school types (private, charter, public). Those teachers became my research point persons and would play a vital role throughout the process. Next I describe the five schools where participants for the study were enrolled.

Site 1: Westpine High School

Westpine High School[1] is located in the Bronx. It is a public high school that is focused on work-based learning experiences, which include college and job visits, job shadowing, and industry-based internships. This school also offers students a learning kitchen, which affords them the opportunity to pursue a career in the culinary industry. The neighborhood, however, is now described as "tough," and as such, many of the windows have been covered with bars and the students enter the building through a metal detector each morning, monitored by a collection of security officers. While the school has had difficulties with discipline, improvement has been noted according to school surveys from parents and school faculty. Westpine High School first opened its doors in 2012 and shares a colossal school building with a charter school. The student demographics as of 2015-16 consist of 2% Asian, 36% Black, 60% Hispanic, and 1% White. The student body is 36% males and 64% females. Twenty-one percent of students have special needs, and 15% of students are English language learners. Out of the 303 students that attend the school, 272 (90%) are economically disadvantaged; 84% (256) of students are eligible for free lunch, and 6% (16) of students are eligible for reduced-price lunch.

In 2017, 80% of students earned enough credits in 9th grade to be on track for graduation, and 74% earned enough credits in 10th grade to be on track for graduation. Sixty-nine percent of students graduated within four years of attending Westpine High school. Eighteen percent of students successfully completed approved college or career preparatory courses and examinations, but only 5% of students graduated college ready, by meeting CUNY's standards for avoiding remedial classes. There are a total of 27 teachers, and of them 70% teach out of certification, 19% have fewer than three years of experience, and 56% have a master's degree.

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[1]All school names and student names are pseudonyms

Site 2: Silvercliff Academy

Silvercliff Academy is a public school located in Brooklyn; it has a specific focus on providing students with competence, training, and critical thinking skills they need to master mathematics and research. Silvercliff Academy was founded in 2013; it too shares an enormous school building with three other 9-12 public NYC DOE schools. Historically, the school has had good state test scores and remains above the city average. The student demographics as of 2015-2016 consist of 271 students, 91% of whom are economically disadvantaged. Eighty-two percent are eligible for free lunch, and 10% are eligible for reduced lunch. Silvercliff Academy has enrolled 3% Asian, 51% Black, 40% Hispanic, 5% White, and 1% multiracial. The student body is comprised 63% of males and 37% of females. Silvercliff Academy has 15% of students with disabilities, and 11% are English language learners.

The school has 19 teachers in total; 5% do not have a valid teaching certificate, 37% have fewer than three years of experience, 63% are teaching out of certification, and 21% have their master's degree or higher. With the wide variety of programs, classes, and activities, 79% of students earned enough credits in 9th grade to be on track for graduation, and 84% of students earned enough credits in 10th grade to be on track for graduation. Silvercliff Academy has a graduation rate at 80% within the four years of attending school. When it pertains to students being prepared for college and career readiness, 39% successfully completed approved college or career preparatory courses and exams. Forty-eight percent graduated college ready and met CUNY's standards for avoiding remedial classes, and 68% graduated from high school and enrolled in college or other postsecondary programs.

Site 3: Marblepond Charter

Marblepond Charter is a public charter school located in Manhattan. The school's inaugural year was 2001, with the focus on molding students to become avid readers, independent thinkers, and intellectually sophisticated children. The expectation is to challenge the students by stimulating their minds with complex questions, which requires deep thinking, and sparks intellectual curiosity. There are 896 students enrolled at the Marblepond Charter, and 82% are economically disadvantaged (60% are eligible for free lunch, with another 14% eligible for reduced-price lunch). The student demographics of this school consist of 80% Black, 18% Hispanic, 1% White, and 1% Multiracial. The student body is comprised 51% of males and 49% of females. Twenty-six percent of the students have disabilities, and 4% are English language learners. The average class size for each grade is 26 students. There are 92 teachers that work for this school, and of those teachers, 34% are with no valid teaching certificate, 8% with fewer than three years of experience, and 75% with master's degree or greater. One thing that makes Marblepond Charter unique is its board of trustees, which has a couple of notable and wealthy names it.

Site 4: Fairbourne Prep

Fairbourne Prep is an all-girls private K- 12 school located in Manhattan. Fairbourne Prep was founded in the 1920s, shortly after women were granted the right to vote, and is known for their state-of-the-art science labs, art studios, performing arts center, gymnasium, and photography labs. This private school offers girls the opportunity to achieve greater autonomy but at a hefty cost; Fairbourne Prep costs upward of $40,000. There are approximately 520 students, of which approximately 80% of students are White. There is a 7:1 student-to-teacher ratio, with 86% of the faculty holding advanced degrees.

Site 5: Moorhall

Moorhall is located in Queens and is focused on developing and enhancing students' skills to enroll in college or prepare them for a career. This school has a rich and long-standing history and offers college level classes, daily literacy programs with emphasis on self-selected reading, a student advisory program, and a teaching institute.

There are 1,124 students enrolled at Moorhall, and 59% of those students are economically disadvantaged. Forty-five percent are eligible for free lunch, and 14% are eligible for reduced-price lunch. The student demographics consist of 24% Asian, 51% Black, 16% Hispanic, 8% White, and 1% American Indian or Alaska Native. The student body is 49% male students and 51% female students. Twenty-two percent of the students have disabilities, and 1% are English language learners. Ninety-one percent of the students who attend this school graduated within four years. Fifty percent of the students successfully completed approved college of career preparatory courses and exams, while 37% graduated college ready and met the CUNY's standards for avoiding remedial classes.

Table 3.1. Types and Location of Participating Schools

Schools:	Type:	Location:
Westpine High School	Public	Bronx, NY
Silvercliff Academy	Public	Brooklyn, NY
Marblepond Charter	Charter	Manhattan. NY
Fairbourne Prep	Private	Manhattan, NY
Moorhall	Public	Queens, NY

Participants

To recruit participants, I went through a mutli-layered process. It began via the presentation mentioned earlier for recruitment of student participants, where students received an informational overview (Appendix A) and parental consent forms (Appendix C). Students who brought the parental forms back within a timely manner indicating their willingness to participate were placed into a pool of participants. Due to a significantly larger pool than originally expected, teachers at the respective schools were recruited to help in the selection process.

Teachers assisted me in identifying students to participate in the study because they have a unique perspective and can select students that would express their views when asked thought-provoking questions. Since the study is based on student perceptions, the main criterion for selection of students was that students were willing to be expressive in sharing their ideas because there was a general concern about student-interviewer rapport needed for a good interview. Though that was the main criterion, some consideration was also given to participant accessibility, diversity (in terms of age, gender, ethnicity, socio-economics, mathematics ability) and availability to meet at a pre-determined time and date for further convenience. Kitzinger (1995) recommends that bringing together a diverse group is one way to maximize the exploration of different perspectives. Therefore, in my study, I used what Patton (1990) calls a purposeful sampling to provide "information-rich cases to study in-depth" (p. 169); focus groups of students were designed that were communicative, expressive, and diverse in respect to a number of factors.

There originally was no real minimum number of student participants. The goal was more geared to depths of understanding (Patton, 2002). Hatch (2002) suggests selecting an ambiguous number just in case more information is necessary; however, Kitzinger (1995) claims that the ideal focus group size is between 4 and 8 people. I ultimately decided to use a sample size of 25-30 high school students (i.e., 5 to 6 students at each school). My rationale for choosing 5 students was because a group of 5 students was large enough to generate rich discussion but not so large that some participants would be left out.

As stated previously, teachers played a vital role in this study; they collected initial paperwork, contacted students, and transferred messages from both sides, all while keeping their respective principals in the loop. Once participants had been confirmed, I conducted this qualitative study at their respective high schools. The second researcher was contacted to take detailed notes while the discussions took place.

Teachers reserved a meeting place with adequate space in their schools—the student library, classroom, etc.—depending on availability and/or participants' preference, with consideration for minimizing distractions. Teachers verified all participant involvement. I provided the necessary equipment, such as the tape recorder, batteries, and notepads, and confirmed that all was in order prior to the focus group date. At the time of data collection, I again introduced myself, orally reviewed the purpose of the study, and read the consent form to the participants in order to verify their willing participation (Appendix B). The focus group sessions, with the meme-sorting activity, lasted approximately an hour. These interviews were semi-structured and audiotaped. The specific questions explored can be found in Appendix H and are summarized in later paragraphs. Participants were given pizza to eat before or while the interview was being conducted as an incentive for their participation.

Though purposeful sampling was used and teachers were asked to balance the interview pool to be more reflective of the general population, there were no original intention of going beyond the group. Hancock and Algozzine (2006) describe such studies as the collection of information with the objective of describing a specific group. This research did not attempt to generalize the findings to fit another population of students or another school system (Stake, 1995). Yin (2017) states that such studies have as a primary objective to investigate a phenomenon in depth within its real-life context. Additionally, Yin defends that researchers can expand and generalize theories that can act as a blueprint to compare and test the results of studies. As such, the researcher is intending to generalize in regard to a particular theory, not the world. The goal of this qualitative study was to obtain a comprehensive understanding of how students described their experiences and perceptions of mathematics in popular culture, and that was achieved. However, this study may have created a framework and insight for future studies that plan to extend beyond a bounded context.

Focus Group Participants

Westpine High. Westpine High School's focus group was comprised of six students from different math classes and different grades. The focus group contained upperclassmen (2 seniors and 4 juniors). The group was evenly split between male and female as well as evenly split between African Americans and Hispanics. The average self-perceived math ability among this group was 6.67, which is at the threshold of students having a "good" self-perceived image of themselves.

Table 3.2. Demographics of Westpine High School's Focus Group[2]

Student Code & Pseudonym	Age	Gender	Ethnicity	Grade	Self-Perceived Math Ability (1-10)
W1-Wilma	17	Female	African American	12	8
W2-Willow	17	Female	African American	12	6
W3-Wilbur	17	Male	Hispanic American	11	7
W4-Wilson	16	Male	African American	11	5
W5-Wakanda	17	Female	Hispanic American	11	7
W6-William	16	Male	Hispanic American	11	7

Silvercliff Academy. Silvercliff Academy's focus group was comprised of all 9th graders within the same algebra honors class. The focus group seemed very close and friendly with one another.

[2]The first letter of each student participant's name corresponds to their focus group name.

The group was comprised of three females and seven males and contained a mixture of African American, Asian, and Hispanic students. The average self-perceived math ability amongst this group was exactly 8, which represents students having a "very good" self-perceived image of themselves as math students.

Table 3.3. Demographics of Silvercliff Academy's Focus Group

Student Code & Pseudonym	Age	Gender	Ethnicity	Grade	Self-Perceived Math Ability (1-10)
S1-Sharon	14	Female	African American	9	8
S2-Sean	14	Male	Asian	9	8
S3-Susan	14	Female	Hispanic American	9	6
S4-Samuel	14	Male	Hispanic American	9	8
S5-Scott	14	Male	Hispanic American	9	9
S6-Steven	14	Male	Hispanic American	9	8
S7-Samantha	14	Female	African American	9	9

Marblepond Charter. Marblepond Charter's focus group was comprised of an assortment of students from different classes and different grades. Two members of the focus group were enrolled in a remedial math class. The most surprising aspect was that the group was comprised of all males in a public charter school. The group was not diverse in terms of gender and ethnicity, as each participant was male and African American. Five out of six participants were in 10th grade, and 1 was in 11th grade. The average self-perceived math ability amongst this group was 8.83, which represents students having a "very good" self-perceived image of themselves as math students. The focus group seemed apprehensive at first and needed an icebreaker before answering questions.

Table 3.4. Demographics of Marblepond Charter School's Focus Group

Student Code & Pseudonym	Age	Gender	Ethnicity	Grade	Self-Perceived Math Ability (1-10)
MA1-Adam	16	Male	African American	10	8
MA2-Alex	15	Male	African American	10	10
MA3-Anthony	15	Male	African American	10	8
MA4-Antwon	15	Male	African American	10	9
MA5-Akil	15	Male	African American	10	9
MA6-Alfred	17	Male	African American	11	9

Fairbourne Prep. As stated previously, Fairbourne Prep is a private all-girls school, so naturally the focus group was all-female. The group was predominantly sophomores, with the exception of one junior. The group was diverse in terms of ethnicity, with two Caucasians, one African American, one Hispanic, and one Indian American. The average self-perceived math ability amongst this group was exactly 7, which represents students' having a "very good" self-perceived image of themselves as math students; however, there was an outlier that skewed the average.

Table 3.5. Demographics of Fairbourne Prep's Focus Group

Student Code & Pseudonym	Age	Gender	Ethnicity	Grade	Self-Perceived Math Ability (1-10)
F1-Felicia	15	Female	Caucasian	10	6
F2-Francesca	15	Female	African American	10	8
F3-Falyn	17	Female	Hispanic American	11	3
F4-Francine	15	Female	Caucasian	10	9
F5-Fae	15	Female	Indian	10	9

Moorhall. Moorhall's focus group was comprised of 9th graders from two different classes. The focus group initially seemed to be divided but overall turned out to be an intimate bunch. The group was comprised of four females and three males and contained a mixture of African American, Asian, and multicultural students. The average self-perceived math ability amongst this group was exactly 8, which represents students having a "very good" self-perceived image of themselves as math students.

Table 3.6. Demographics of Moorhall's Focus Group

Student Code & Pseudonym	Age	Gender	Ethnicity	Grade	Self-Perceived Math Ability (1-10)
M1-Mike	14	Male	African American	9	5
M2-Maureen	14	Female	African American	9	8
M3-Michelle	14	Female	Mixed	9	9
M4-Melissa	14	Female	Mixed	9	8
M5-Mark	14	Male	African American	9	8
M6-Matt	15	Male	Asian	9	9
M7-Mary	14	Female	Asian	9	8

Overall, there were 31 students that participated in the study; approximately 52% (or 16) were males and 48% (15) were females. The study contained 29 underclassmen (high school students who are not seniors), which comprised 94% of the sample: 14 (45%) participants were in 9th grade, 7 (29%) participants were in 10th grade, 6 (19%) participants were in 11th grade, and only 2 (6%) were seniors. No participants were 18 years of age or over. My sample contained 15 (48%) students that identified as African American, 8 (26%) students that identified as Hispanic, 3 (10%) students that identified as Asian, 2 (6%) students that identified as Caucasian and "Mixed," and 1 (3%) student that identified as Indian. Student self-perceived math ability was captured on a 1-10 number scale, with 1 being the lowest and 10 being the highest. When analyzing the data, I broke the number line into distinct categories: excellent (10), good (7-9), average (4-6), bad (1-3), and poor (0). The average self-perceived mathematics ability (SPMA) was 7.69, with a standard deviation of 1.5. In total, 3% of my sample identified as a bad mathematics student, 16% identified as average students, 77% identify as good mathematics students, and 1 student identified as an excellent student. Approximately 80% of my sample identified as having above average mathematics skills.

Pilots

There were two previous small pilots facilitated by myself and another researcher, Gabor Salopek, which assisted in the creation of instruments and format of the current study.

Pilot 1—Focus Group Questions

Questions were borrowed from previous researchers as well as created as part of a class final project. The pilot consisted of 25 Likert-Scale questions and four constructed responses geared to quantitatively analyze students' perceptions of mathematics and popular culture (Appendix I). This gave the researchers insight into students' definitions of popular culture, students' interaction with popular culture, questioning protocol, coding analysis of mathematics memes, and possible uses or influences of popular culture. The results of the pilot study indicated a number of findings, such as students believing that popular culture valued other subjects more than mathematics, however there were several limitations. Nevertheless, the pilot led to newly developed questions and the creation of a thought-provoking protocol that would contribute significantly to enhancing this study's design (Lim, 2012).

Pilot 2—Collecting Memes

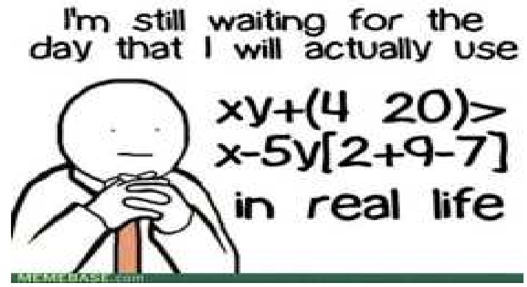


Figure 3.1. Mathematics Meme

The collection of memes was an interesting process. This first meme (Figure 3.1), was placed on my desk by a former student. As he left the classroom, he shouted out the words "told you," as if this meme was the reassuring factor to prove mathematics was not important. This was the first mathematical meme I encountered during my years of teaching, and it served as a catalyst for my study. I received four more mathematical memes from former students at various times, all with negative messages about mathematics.

After hearing such unfavorable points of view about mathematics from my students, I discussed it with my academic and professional networks, who provided me with more mathematical memes—all with negative messages about mathematics. When petitioning, my networks had not produced one positive mathematical meme, which assured me that this matter was worth a closer examination. So I decided to make memes the emphasis of study.

Since memes have grown in popularity and exposure, I decided to undertake a Google search to see what it might produce. I typed in "math memes," and instantly hundreds of memes appeared with categories such as "funny," "student," and "story problem" displayed above them to help me further dissect my search. Approximately 63 memes pertaining to mathematics were copied and placed into a databank. The researchers then separated the memes into positive (images that emphasize good and laudable characteristic about mathematics), negative (the exact opposite) messages, and neutral (doesn't really impose any feeling about mathematics, i.e., can't be taken in a positive or negative manner). The division revealed 37 negative mathematical memes, 17 neutral memes, and only 9 positive ones. This shocking discrepancy alone encouraged me to continue pursuing this investigation. In an effort to balance the inventory, I carried out several other Google searches, looking for neutral and positive mathematical memes. I typed in “positive math memes,” and at first glance the search proved to be a successful one. But after deeper exploration, the search produced 10 new memes (3 positive and 7 neutral) that were added to the inventory, and the rest of the memes found just mimicked the previous searches, with more negative memes.

The Google searches soon became redundant and ineffective, so I elected to change the search method and proceed down a different avenue. I began using social media platforms such as Instagram, Tumblr, Pinterest, and Facebook to search for more memes. These searches, too, soon became meaningless, as they just continued to produce replicas of existing inventory items. But Facebook in particular became unique. Facebook is known as the largest social media outlet as measured by total number of accounts created and total number of members. A colleague advised me that Facebook had a math lovers group with its own page and separate website where merchandise can be purchased (the webpage and link are provided in Figure 3.2).

Figure 3.2. Facebook Page (https://www.facebook.com/MyMathElation/timeline)

The page states in its description to ““LIKE” if you love MATH!” On Facebook, clicking “like” can mean various things: it could be amusing, it could be appreciated, it could state an agreed upon stance, etc. Everyone and every page could have a different opinion to why a “like” is important, but I think it shows an expression of affinity and indicates the visitor has an interest, which leads to more notoriety.

More importantly, in the description section, the page states that it has apparel with "daily math memes, jokes, news, and more." This group page produced 15 memes (4 positive, 4 neutral, and 7 negative) to be added to the inventory.

The inventory collection was capped off at approximately 85 memes, collectively (negative, positive, and neutral). My exploration and collection thus far led to roughly a 3 to 1 ratio of negative memes to positive memes and approximately a 2 to 1 ratio of negative memes to neutral memes; so approximately 50% of the inventory thus far was negative, 32 % was neutral, and 18% was positive. Closer observation led me to some eminent preliminary findings. After an examination, it seemed apparent that popular culture has particular views about who can be good at mathematics and how people who are good at mathematics look. There were commonalities between a majority of depictions and representations in both categories. It seems as though the majority of positive mathematics memes had images of Caucasian males or Asian males with glasses. These results alone assured me of my purpose and reinforced the motive for conducting my study.

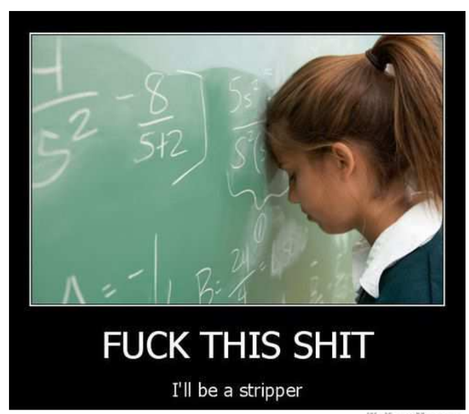


Figure 3.3. Negative Mathematics Meme

Surely having students analyze 88 memes would be overwhelming and unrealistic, so some memes had to be discarded. I began consulting with my advisor because I was unsure on how to select criteria that would reduce the inventory in an effective, non-biased manner. She advised that my projected audience was 13 to 18 and there were ethical standard principles associated with them. While performing my study, I did not want to expose participants to memes having an inappropriate nature (graphical nature or derogatory remark) or memes that would cause a loss of innocence. We elected to unselect memes that had an emphasis on racial or gender issues, used profanity, and/or used explicit language. For example, Figure 3.3 was eliminated due to its strong content and inappropriate language.

The inventory was approximately down to half of its original size after excluding memes that did not fit the criteria. Fifty entries (28 negative, 9 positive, 13 neutral) were still too large a sample for students to view. Mindful of interview fatigue, I considered the final inventory to consist of 9 memes in total, evenly distributed across types (3 neutral, 3 positive, 3 negative). So I utilized a jury method to help decrease the 50-meme inventory down to 9 memes. I assembled a 10-person jury selected from my personal network of colleagues, mathematics and science professors, high school teachers, and popular culture professionals in an attempt not only to decrease the number of memes but to select the three most unanimous memes for each category. The panel of jurors were then assigned a copy of the meme inventory, an Excel spreadsheet, and a set of directions, which stated:

> *Good evening, thank you for taking timeout of your busy schedules; I really appreciate it. I have attached the meme inventory along with an Excel spreadsheet to record your thoughts. The memes will be shown to high school students between the ages of 13-18. Please keep that age group in mind and select the most appropriate option (Positive (P)/Negative (N)/ Neutral (O)/Undecided (U)). Each meme you are presented with has a suggestion box to its immediate right. Please feel free to make any suggestions to an existing meme, and the researcher will take those into consideration before the study is executed. Also please feel free to highlight any meme that you extremely like or dislike, and those too will be taken into consideration. Thank you again for your help.*

The selection choice "*undecided*" was added to allow jurors to state they had no opinion or had not thought about a particular meme. Subsequently adjustments needed to be made when tallying the inventory sheet (Appendix K). To ensure reaching an end to the process, prospective memes were selected pending an 80% consistent threshold. In other words, at least 8 jurors would have to have identical answers for a meme to be selected. Though 3 memes was the intended amount, ties (equal amount of votes) between memes are practical and were expected, but this approach limited ambiguity between the messages of selected memes.

As a result of the jury selection process, 5 positive memes, 8 neutral memes, and 15 negative memes were all unanimously chosen, and all others were discarded. However, jurors stated that some of the selected memes had similar captions and others had identical pictures; therefore, similar memes were discarded. Researchers did not dispose of any positive ones chosen and discarded 3 neutral memes, placing emphasis on popularity for this generation of students (i.e., a meme containing Chuck Norris probably wouldn't be as intriguing as he once was). Selecting the negative memes was a little more difficult, because there were three times the number needed. Examining the 15 negative memes closer, the researchers decided to partition the set into 3 based on the clearly analogous messages: memes that stressed confusion, memes that stressed math difficulty, and memes that expressed math as insignificant or not needed. Of the 15 negative memes, 9 emphasized confusion, 4 emphasized difficulty, and 2 emphasized lack of importance. The researchers discarded negative memes that were similar to others in the group and decided to select 3 "confusion" memes, 1 "difficulty" meme, and 1 'no value' meme to make the final group proportional to the 15 original negative memes.

Aware of the subjectivity used, the researchers elected to facilitate another small pilot to finalize the meme inventory down to 9 mathematical memes and to ascertain that the methods used would not induce ambiguous results. Each meme was coded (i.e., the numbers underneath the meme). The second pilot was an exploratory semi-structured interview designed to deliver insight on the questioning protocol and coding analysis of memes. The pilot was completed through a series of three focus groups containing twelve participants. Focus groups were created based on the number of students who were willing to participate and their availability.

Table 3.7. Inventory Used for Pilot Study #2

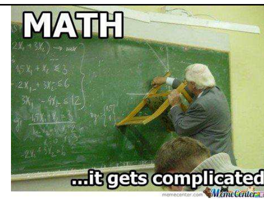
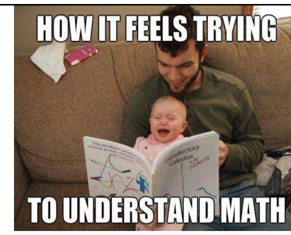
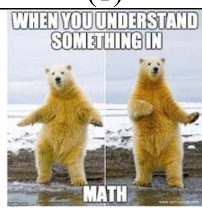
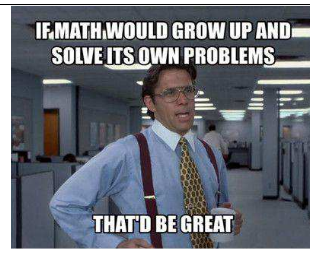
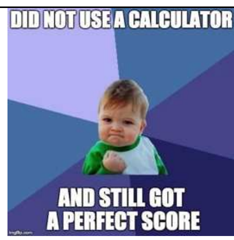
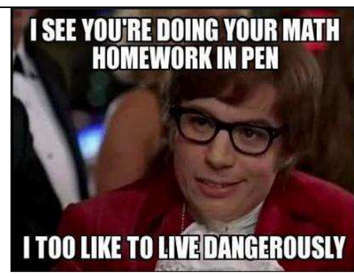
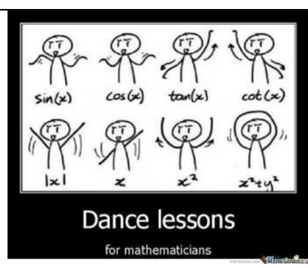
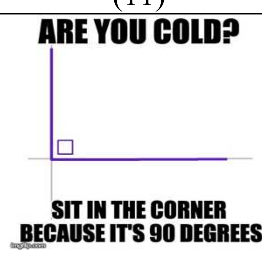
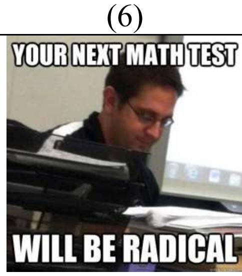
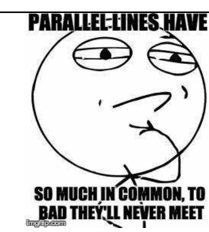
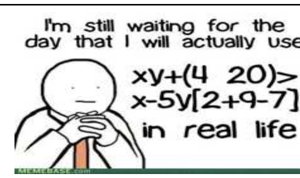
Positive	Neutral	Negative
 (1)	 (4)	 (9)
 (5)	 (3)	 (2)
 (12)	 (11)	 (15)
 (6)	 (10)	 (13)
 (7)	 (14)	 (8)

Table 3.8. Focus Group Participants for Pilot Study #2

Focus Group	Number of Males	Number of Females	Total # of Participants
A	2	2	4
B	2	1	4
C	3	2	5

As recommended by Creswell (2012), the pilot focus groups were audiotaped and transcribed for analysis. The researchers thought it more effective to capture information using an assortment of methods to gain a more in-depth sense of which types of messages were being received and which memes would elicit more thought. Therefore, along with conducting a focus group, the researchers also created a *student activity sheet* (Appendix I) to capture the participants' individual thoughts from the matching activity. The students were presented with all 15 mathematical-referenced memes and were asked to identify messages that were being portrayed, describe whether they supported or rejected the intended message, and which meme stood out the most. The results of this pilot study too indicated a number of findings. For example, students often used "*positive*" or "*negative*" to describe and categorize the mathematics memes. Additionally students who verbally identified as "good math students" did not internalize any of the negative mathematical messages. They often rejected the mathematical messages illustrated by memes saying it was "Not true" and/or "This is just a joke." Additionally, students who self-identified as not interested in mathematics did internalize and agree with a lot of the negative mathematical messages. In a particular case, one student said, "This is me, in class every day! [referring to meme 15]." Though there were limitations due to various degrees of bias, the pilot led to enhancing this study's design by aiding to the finalization of the meme inventory and some important procedural edits for the study (Lim, 2012).

As a result from this pilot study, memes coded as 7, 8, 9, 10, 12, and 14 were discarded due to a declaration of ambiguity from a majority of focus group participants.

The final meme inventory contains 9 memes in total: 3 positive, 3 neutral, and 3 negative. A new code (numbers 1-9) was generated to refer to the memes (i.e., the numbers underneath each meme).

The students' responses provoked several procedural changes and therefore, rather than inquiring about their perceptions of *all* memes, the researchers decided to have the students group them as positive, negative, and neutral and write what made those collective memes positive, negative, or neutral. The student activity sheet was also modified as a result. The pilot also led to the addition of a self-perceived math ability scale on the student activity sheet.

Data Sources

Two instruments were used to gather information about the students' perceptions of messages about mathematics found in media: focus groups and an individual meme sorting activity. Both instruments went through a pilot test and a series of revisions to ensure materials were unprejudiced, credible, dependable, and valid. Each participant engaged in both activities. A focus group protocol and individual meme activity protocol were created and employed to secure more information, because there is an immense amount of complexity when capturing an experience. Scholarly resources were consulted to aid in the creation of both instruments to ensure consistency throughout the procedure and minimize variation across the participants.

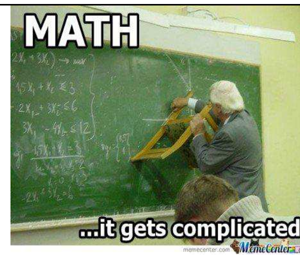
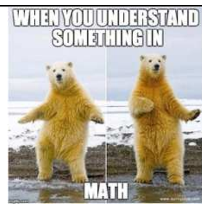
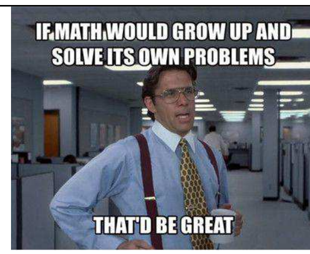
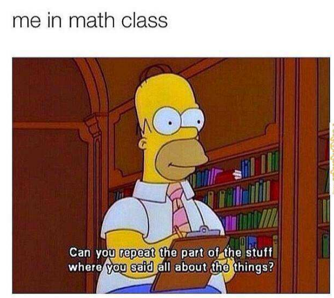
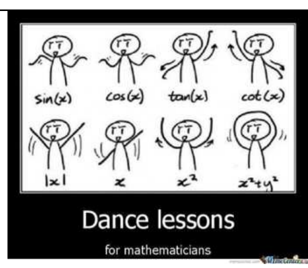
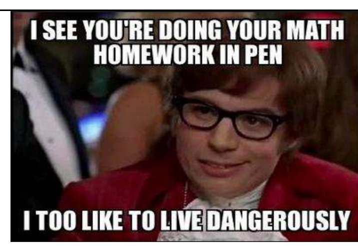
Final Focus Group Question Protocol

For the current study, the focus group's designed questions were based on the conceptual frameworks of Michael Appelbaum, Shelby Paige Morge, Elizabeth Marshall, Özlem Sensoy, Donna Alvermann, and Danny Martin, who have all performed extensive research about mathematics and popular culture. It is important to note that during the focus group, I used a semi-structured protocol, which is particularly known to be effective when “investigators are interested in understanding the perceptions of participants or learning how participants come to attach certain meanings to phenomena or events” (Berg, 2009, p. 110). It allowed me to ask probing questions in order to obtain clear information. This form of research allowed me to ask a series of impromptu questions to participants to stimulate further discussion and thereby understand through further analysis the meaning of the additional interesting information (Marvasti, 2003). The format of my focus group questions often alternated between structured questions and probing questions. Both responses were equally important; directed questions allowed me to ground the conversation and look for specific responses, while the probing questions allowed the conversation to wander into unexpected territory. It also appeared the children felt more comfortable expressing their opinions in this more fluid discussion format. The questions underwent a series of checks, which included the pilot study stated above. Professors and colleagues with expertise in mathematics education, popular culture, and related fields were asked to read over the questions and offer any feedback on the clarity and conciseness of the instrument. Adjustments were made accordingly. The first set of ten questions included in the instrument focused on background, social media experiences, perceptions about mathematics in popular culture, student definitions of memes, and what students believed to be the purpose of memes. Students then stopped answering questions to participate in a meme-sorting activity. The sorting activity gave students a break from the traditional interview format and provided an intricate perspective that helped participants formulate and solidify their thinking. The second set of seven questions was more targeted toward subconscious messaging and whether or not students believed that messaging was impactful. The questioning protocol is located in appendix H. A second researcher, Gabor Salopek, with mutual consideration to mathematics and popular culture was brought on board to assist when necessary.

Final Meme Inventory

Table 3.9 contains memes total, positive, neutral and negative.

Table 3.9. Final Meme Inventory

Positive	Neutral	Negative
 (7)	 (6)	 (8)
 (2)	 (9)	 (3)
 (5)	 (1)	 (4)

Focus Group Format

According to Creswell (2012), the scheme should be explicitly focused on the topic at hand or “interview fatigue” could detract from meaningful questions and answers. Therefore the focus groups were split into three distinct parts.

Part I—Initial Questioning. The first part was the initial focus group questioning, which helped build comfort for participants and generate ideas. Focus groups were used to better illuminate the norms and perspectives of high school students as well as the range of perspectives that exist within their community, and people's idiosyncratic opinions about their own values, which become extremely beneficial to use when examining education because, as stated previously, education is a social construct. A principal advantage of focus groups is that they yield a large amount of information over a relatively short period of time. The focus group phase, in particular, focused on whether or not they had seen mathematics in popular culture, and if so, was it positive or negative, and other questions of this nature. Having students talk about their perspectives would make them more aware of what might influence their thoughts and feelings about a topic (Lincoln, 1995).

Part II—Individual Meme Activity. After the initial set of questions, participants were asked to participate in an individual mathematical Internet meme-sorting activity in which they were to place memes into groups (i.e., positive, neutral, negative) and explain briefly their decisions for coding the memes the way they did. This gave student participants an enjoyable feeling to a rather mundane task. The individual Internet meme sorting activity was used to capture personal voice, beliefs, and feedback on particular memes. It also was an interactive way to individually examine the students' own impressions and formulate whether or not they believed messages in mathematical memes were being internalized. This analysis of meme activity incorporates Stuart Hall's (1997) notion of intentional visual representation, discussed previously.

Part III—Concluding Questioning. The third section transitioned participants back to answering questions with immediate information at their disposal. Participants themselves were in control of their words and thoughts after the individual meme activity and had unrestricted rein to express whatever they felt comfortable to share, which is the most desirable way to discover and explore personal accounts (Bryman, 1992). The intention was that participants would grapple with their earlier thoughts and not only develop but articulate strong rationales on whether or not they believed students were internalizing messages found in popular culture.

Summary of Data Sources

Though the preliminary stages of doing this study took approximately four months, the data collection period was relatively short. The data were collect over a two-month period, from January to February 2017.

Each of the 31 participants engaged in both the focus group protocol and the individual meme activity. One approach was direct (focus group), where students answered questions that were aligned to the stated purpose, and the other approach (meme sorting activity) was indirect, where students' perceptions were deciphered through an activity. Both were designed to allow me to engage with participants in reflective and reflexive conversations in order to produce insights about whether popular media has an influence on students' mathematical identities and how individuals are internalizing their experiences (Creswell, 2007).

All data were collected in accordance with my IRB guidelines and involved informed permission from each participant. I explained to each participant the purpose of my research, the potential risks, benefits, and anticipated scope of time for participation and highlighted that all interviews would be recorded to ensure accuracy. To assure that participants understood what was stated, I asked follow-up questions, mainly about the purpose, benefits, and procedures of the study.

Data Collection Methods

As stated earlier, I adhered to Yin's (2017) recommendation of data collection methods and included multiple sources, such as focus group interviews, documentation, and physical artifacts (individual meme sorting activity). My intention for collecting multiple sources of data was to triangulate the focus groups' transcripts, with participants' artifacts from the meme-sorting activity, as an ideal approach to assure the validity of my research. Responses were also analyzed with respect to grade, gender, and self-perceived mathematics ability. As Miles and Huberman (1994) explain, triangulation involves using multiple measures and sources of the same phenomenon, all of which will be coded for similar themes. To ensure accuracy and trustworthiness, I audiotaped and recorded all focus group conversations, and, with the assistance of a research assistant, extensive notes on phrases, sentences, actions, concepts, body language, opinions, and quotes were acquired at the same. Transcriptions were done the same days as the actual focus groups. In addition, I scheduled timely meetings with my dissertation advisors to discuss questions surrounding methodology, findings, and results.

Reliability and Validity

For me, the roles of researcher and learner complemented one another, and both identities were used as an interaction quality in the research process. However, as Cobb (1995) points out, one needs to decenter oneself to "appreciate the other position" those other participants may have and allow to be observed, "even when it is difficult to argue for it from their own perspective" (p. 25). Reliability and validity also are often concerns when discussing qualitative research, but according to Kincheloe and McLaren (1998), when it comes to qualitative research, the traditional definitions of validity and reliability transition slightly to take on new definitions. Kincheloe and McLaren state that qualitative validity and reliability are more aligned with the "extent to which a researcher's observations capture descriptions of a particular reality" (p. 287). Kincheloe and McLaren, along with Shenton (2004), assert that trustworthiness is a more

Table 3.10. Data Collection Methods

Research Question	Data Source
1. What messages, if any, are students receiving about mathematics from memes in popular culture?	*Focus Group Transcripts*: • Pay attention to specific questions, listen for common themes, highlight relevant experiences and interesting quotes *Individual Meme Activity*: • Compare and contrast jury's coding of positive, neutral, negative between participants' coding • Pay attention to specific experiences and themes in participants'' written responses
2. If messages about mathematics from memes in popular culture are received by students, how are they internalized?	*Focus Group Transcripts*: • Pay attention to specific questions, listen for common themes, highlight relevant experiences and interesting quotes • Examine how participants described what type of memes they would create, share and "like". • Examine the comments they would leave
3. How are associated messages from memes influencing the construction of mathematics identity?	*Focus Group Transcripts*: • Pay attention to specific questions, listen for common themes, highlight relevant experiences and interesting quotes • Participants' excepts about their preference to let their hypothetical younger sibling view mathematical memes

pertinent measure. In order to achieve trustworthiness, materials were vetted and went through a series of revisions by colleagues, mathematics education professors, and popular culture professionals. Materials were then aligned to Guba's (1981) trustworthiness framework, which ensures that consistency and dependability can be achieved through four criteria:

(a) Credibility (in preference to internal validity);

(b) Transferability (in preference to external validity/generalizability);

(c) Dependability (in preference to reliability);

(d) Conformability (in preference to objectivity).

Data Analysis

As Miles and Huberman (1994) assert, a systematic and coherent process prior to data collection and management is needed when dealing with qualitative research. I used the grounded theory approach to systematically examine all data and converge them to several open codes of information (Creswell, 2012). I reduced my data by considering my research questions and my theoretical framework, displayed my data in charts and tables, and then drew conclusions.

Table 3.11. Data Display for Table for Each Interview

QUESTIONS	NOTES/ QUOTES	THEMES

The transcription data were broken down into codes that linked to frequently repeated ideas or comments, reference to the literature, shocking or surprising remarks, and or interviewee explicitly stating his or her thinking. I gathered additional information by dismantling dichotomies, noting contradictions, and interpreting metaphors. As such, I organized my data through several different lenses and by several different variables (i.e., grade, gender, and self-perceived mathematics ability/SPMA).

I constantly compared data from the focus groups with data from the individual meme-sorting activity to find any connections between responses. Throughout my data collection, I also managed data by what Miles and Huberman (1994) call indexing, a process of defining codes according to my research questions and theoretical framework, organizing them into a structure, and pairing codes with specific parts of my data. I kept notes and checked them against transcriptions in order to ensure consistency. Codes were dissected and combined with others to form underlying categories or themes that are interconnected through using an axial coding system.

Table 3.12. Data Analysis Framework

Questions	Westpine High School	Silvercliff Academy	Marblepond Charter	Fairbourne Prep	Moorhall	Common Codes

Data were cross-referenced between cases and examined if any correlated with other data. Articulating the complex meanings of participants' experiences is no small feat (Teppo, 1998). A hierarchical tree diagram was created and used to interpret the connectivity between themes and codes. I then used selective coding to help build and illustrate a story to connect the codes, themes, and categories to a central phenomenon. Additionally, I incorporated my knowledge of mathematics education in society to draw conclusions. Miles and Huberman (1994) explain that drawing conclusions is the last phase of qualitative research, but interpretation is a necessary and crucial component of the qualitative approach. The tree diagram demonstrates information from the coding phase into a figure that represents the theoretical framework of the process used in this study.

Furthermore, codes, themes, and categories will later be explained in the results section.

Limitation of Methods

Though my goal was to remain impartial and unbiased throughout the creation, data collection, and analysis process, which I believe was achieved, limitations are the factors that may affect the results of the study and that are generally beyond the researcher's control (Hancock & Algozzine, 2006). I am aware that my role and experiences do play a part in the questions asked, the memes that were collected, and the messages that were highlighted, along with themes and codes that were created. Even carefully collected data and results can be misleading if underlying biases are not recognized (Maxwell, 2005).

Limitations of Location and Sample

The findings from this study can be informative but also limited. Perhaps the most dramatic limitation of my study is the location. As I shared, my study took place exclusively in New York City, the largest school district in the United States, and relied heavily on my professional network. Though I petitioned several principals and other school administrators, student participants were difficult to come by. I found that petitioning teachers to give a small presentation during their class granted more access to student participants. Therefore, I decided to utilize teachers within my professional network as my research liaison because there was an implicit level of expectation and trust teachers needed to possess. As a result, my sample was not randomly chosen, and such procedures decreased the generalizability of the findings (Creswell, 2007). However, as Jennings (2012), the head of the Center on Education Policy (CEP), explains, as studies document, the voices of few may seem limiting, but we need to understand what is happening so that larger, more comprehensive studies can provide more information.

Limitations of Focus Group and Meme Selection

Though there are many advantages to using focus groups, there are many disadvantages. A well-known limitation when facilitating focus groups is reactivity (individuals alter their answers due to being interviewed). Focus groups are primarily participant dependent. Even with a structured script, they cannot be replicated, which is why I agreed to the semi-structured questioning format. One-time focus groups are extremely difficult for participants and researcher to build rapport, which in turn makes it difficult to hone in and focus on individual identities. Another limitation was that teachers selected the final student participants to partake in the focus groups. The average self-perceived mathematics ability (SPMA) was 7.69, which signifies a “good” mathematics student, which might indicate that teachers selected their more exceptional students.

Though the meme selection process went through several vetting cycles by professors and colleagues, there is still some degree of bias to consider. Furthermore the meme inventory was primarily dependent on Google searches on the Internet and social media searches, which not only had an abundance of stereotypical messages but also a plethora of stereotypical characters as well (i.e. older White and Asian males). As a result the final meme inventory had a heavy bias on male figures.

Summary

Chapter III has described, in detail, the processes and procedures I used to examine and interpret the data collected. Furthermore, I explained the creation process of both materials (focus group question protocol and meme selection process) used to elicit information. I elected to use focus groups and an individual Internet meme-sorting activity to capture the ways in which students are interpreting and negotiating the messages about mathematics found in popular culture, specifically memes. Based upon the intentions of my study, I justified the importance of using multiple sources for data collection to validate my research. This chapter also clarified the data analysis process I chose to use, which will be explained in further detail with examples and excerpts in the following section.

Chapter IV

RESULTS

In this chapter, I present my findings about messages students are receiving from memes of mathematics found in popular culture, whether or not those messages are being internalized, and how messages are influencing students' mathematics identities. Examining Reyes and Stanic's (1988) original framework (Figure 2.1), I chose to emphasize and examine the societal influences (i.e., popular culture) that may be disseminating messages regarding students' mathematical identities. The results are reported in categories that "reflect the purposes of the research" (Merriam, 1998, p. 183).

I begin this chapter by using transcribed focus group conversations to examine how participants defined memes themselves. I then present the research findings in three sections, one for each research question. In the first section, I answer research question 1 (i.e., What messages, if any, are students receiving about mathematics from memes in popular culture?). The data to answer research question 1 came from three sources: field notes of participants' descriptions of the mathematical memes they have observed in their daily interactions as a reference to messages students were receiving; the Individual Meme Activity (IMA), where participants got to formulate their impressions of positive, neutral, and negative memes individually to compare and contrast their sentiments with those of my jurors; and lastly by examining the transcribed interviews, dissecting pertinent information, and identifying specific overlapping ideas where participants characterized messages about mathematics from memes.

In section two, I answer research question number 2 (i.e., If messages about mathematics from memes in popular culture are received by students, how are they internalized?) by examining and analyzing participants' descriptions of mathematical memes they would create and comments they would leave accompanying the memes circulated. Furthermore, I evaluate transcripts and notes from the focus group discussions for indication of internalization. Lastly, I answer research question 3 (i.e., How are associated messages from memes influencing the construction of mathematics identity?) by analyzing transcripts and field notes. Moreover, in section three, I choose to emphasize participants' characterization of a meme's purpose, participants' justification of whether or not they would display memes to their younger siblings, and participants' personal accounts of memes' influence.

Though I considered my research questions while facilitating the focus groups, I tried not to jump in and steer the conversation. I wanted to preserve the authenticity of the participants' responses. Both common and uncommon responses were included in this dissertation to shed some light on the focus group participants' range of beliefs about popular culture's influence on mathematics identity. Following the investigation and report from the three research questions, I conclude with a summary that combines all the collective data from research questions, providing more insight than individually examining the accounts. Tables and figures are also used and included in this chapter to allow for simple and constant comparisons (Merriam, 1998) among the participants with respect to the way they responded to certain questions.

Definition of Memes

First, I tried to ascertain whether participants knew what a meme was and had ever been exposed to it. As soon as the question was asked, every child in the focus group could not only tell me how they defined it, but also articulated where they saw it, and surprisingly described it. Generally, participants' definitions of memes were similar and contained five main worlds: "picture," "words," "entertaining," "relatable," and "funny."

Scott from Silvercliff Academy said, "Most memes have been in the Internet mostly for like relatable things…. It has to be something related to like the person." Antwon from Marblepond Charter stated, "It's a picture used to send a message of some sort." Francesca from Fairbourne Prep confirmed, "It's like a post could be picture like relates to the words either on top of it or on the picture itself," while Falyn from the same school added, "It's funny and entertaining."

Focus group members had an opportunity to voice their opinions, and collectively in each focus group they defined memes in the same manner more or less—as a picture with a statement relaying a relatable message that can sometimes be perceived as funny. While articulating their definitions, some participants made some notable comments, one being Felicia from Fairbourne Prep. She stated, "It's [a meme] a picture or something and then a phrase on top of it that can commonly relate to a lot of people." Though that does not differ much from the collective definition, I found it interesting that Felicia attempted to quantify the word "relate" to a lot of people, almost to say the message is intended to be widely known or understood. Other interesting remarks came from Alfred and Akil from Marblepond Charter, who defined a meme as:

Alfred: I'll say an inspired comment or ritual.

Akil: Entertainment, sometimes it could be propaganda.

Alfred's use of the word "ritual" may seem odd at first, but by definition a meme is defined as an element of a culture that is passed from person to person, which can also be used to describe a ritual. Akil defined a meme as propaganda, which can be thought of as ideas, or rumors deliberately spread. This is interesting because mathematics is often viewed negatively and is often stereotyped. Akil may have been acknowledging and agreeing with that fact.

This section of the chapter focuses on answering the fundamental questions that originally triggered this exploration. Throughout the sections, my voice is included to summarize, clarify, and interpret the focus group participants' statements. At times, I repeated the question and the verbal responses to reinsure comprehension and help participants provide a stance. To help clarify participants' statements, I chose to make syntax changes and removed the linguistic "filler," the hesitations, false starts common to oral discourse (Berry, 2008). Some interpretations are based on the answer to probing questions, additional comments made, or non-verbal cues that are not included in the conversation excerpts presented here.

Research Question 1

What messages, if any, are students receiving about mathematics from memes in popular culture?

Multiple data sources and frameworks were used framework to extract information and ultimately answer research question 1. First, participants individually described mathematical memes they had observed previously to explore messages students were receiving and messages they same to remember. The field notes were analyzed, and common themes were extracted. Second, students shared their perceptions (positive, neutral, and negative) of memes involved in the meme inventory to gather a more detailed definition of "*positive,*" "*neutral,*" and "*negative*." Lastly, focus group conversations were examined for specific parts and the perceptions of mathematical memes and any underlying messages contained within the memes.

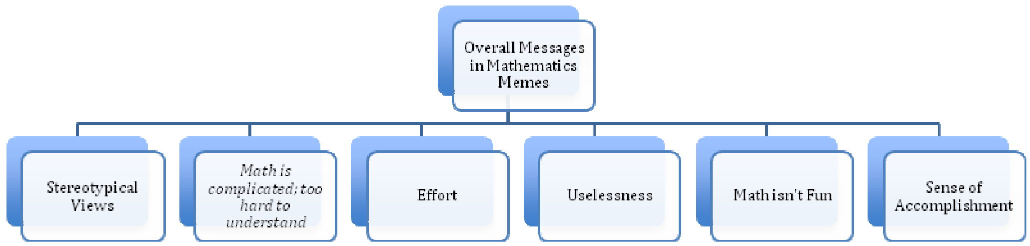


Figure 4.1. Summary of Meme Messages

Descriptions of Memes

Prior to exposing the participants to memes from the prospective inventory, the question, “Have you ever seen memes portrayed about mathematics?” was posed. This question was asked to provide insight into the mathematical memes participants have observed and the underlying messages they might support. Some conversations were lengthy in order to fully document participants’ sentiments. I discuss the findings according to the school sites.

Westpine High School (n = 6). Westpine High School, a small group of students participated in the focus group. They discussed the memes they had seen in social media. For example, Wilma talked about how memes can “go viral” on Facebook: “Sometimes on Facebook, they will have some type of picture where they make it like a little quiz. And people will start debating … it goes viral quickly.” Wilma was referring to an order of operation meme, so I then asked students if they knew what she was referring to. “These are problems like four plus four minus six times four and it’s like what’s the right answer?” And you see a lot of different answers. Two of the students commented:

Wilma: And they make it so tricky because they both seem right.

Willow: There was another one for example where they used like pictures to represent like numbers. They would say like an Apple = 3, Banana= 4 and they would put them together and you got to figure out how much does it add up to.

The students were familiar with seeing different types of memes in social media. In addition, Wakanda commented that she saw another example of a mathematical meme:

Figure 4.2. Negative Mathematics Meme

> Wakanda: I seen this video and it was these little Lemur cats, and they were pretending to be in a math class. And some math teacher was like "if 4 equals s then we put s into the equation …" and the lemur cat is falling asleep and he's getting bored in the class.

Wakanda further added one more example of a mathematically related meme she had seen:

> Wakanda: Umm…There was another one about a really complicated math question, and there was this cat and this cat had its eyes really huge like so surprised about the question. I seen a bunch of them about common core in elementary schools problems as well.

Then William added:

> William: I've seen one where there were 4 cubes connected with water, and you have to figure out which one fills up faster.

As a final example, Willow stated seeing a meme about a person getting slapped:

> Willow: There was this meme where the man looked like he was going to slap someone; he was like this is for people who say math is easy.

I was able to find the meme similar to what she was referring to, which is Figure 4.2.

It is interesting that students remembered such vivid examples of the mathematics memes all carrying their individual message. Of the memes mentioned by three of the participants (Wilma, Willow, and William), they are actually mathematical problems, which are considered neutral because they do not impose any feelings about mathematics. The examples of memes the students shared can be categorized by content (i.e., Wilma's description of order of operations, Willow’s description of systems of equations, William’s description of fluid dynamics). It is curious that Wilma stated that the answers to an order of operation meme are tricky. She insinuates that the mathematical problems themselves are simple but difficulty comes if you make a procedural error, then that respective answer would still be a likely choice. Having multiple answer selections that align to multiple procedural misconceptions raises the level of difficulty. The other three memes that the participants gave had negative mathematical connotations. Wakanda’s description of a meme is considered negative because it has an underlying message that mathematics is boring. In the meme, the lemur is falling asleep in mathematics class due to boredom. Wakanda’s second description of a meme is also considered negative because the cat’s face shows fear and this reinforces that mathematics is scary and students should be afraid of it. Willow’s second description of a meme is considered negative also because it alludes to the frustration people can have when doing mathematics. Lastly, no student in this focus group mentioned or recalled any positive mathematics memes.

Silvercliff Academy (n = 7). When discussing what mathematical memes they have seen on social media with the Silvercliff Academy focus group, instantly Samantha started describing a meme designed around a mathematics problem. Samantha stated, “…they do have those like little math quizzes, it’s like a banana, a McDonald’s fry, and then a cup, and they ask—can someone help me figure this out?” Figure 4.3 is a representation similar to what Samantha was referring to.

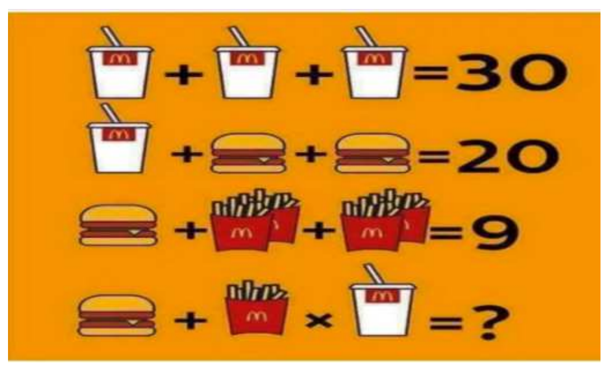


Figure 4.3. Neutral Mathematics Meme

Samuel interjected that most mathematical memes are random, stating, “I don’t know like, using the Arthur meme,” as an example to reinforce his point. He then concluded though all mathematical memes may seem random; they do have one thing in common. Samuel stated, “They’re mostly making fun of math.” Samuel used another example to prove his point: “Like that moment when you study for a test but you still got a zero.” When he was done, several of the focus group participants began to laugh and nod in agreement.

Sharon directed the conversation back to examples of memes like Samantha stated above and said, “Those ones with like, like it shows like a math problem and then they put it on the stop sign. It was like they think this is how math is in life. Like you know, you need to solve it for everything.” Samantha quickly added, “It’s like just math questions, like math quizzes and stuff, and people just get it wrong and say, ‘This is why I failed math.’”

Just as the conversation was about to shift gears, Samuel jumps back into his point and said, “Like every meme that is making fun of math, it’s either this like guy making a dumb face.” Sean added, “Or like a girl rolling her eyes.” Both characteristics illustrate the insignificance of mathematics. And Scott finalized the thoughts of that particular segment of the conversation by describing a negative mathematical meme he had seen before of Mr. Krabs from *SpongeBob Square Pants*. Scott described Mr. Krabs trying to solve a problem, but he looked “confused, dazed out … Mr. Krab had like some kind of effect on him.” Figure 4.4 is an example similar to what Scott described.

Figure 4.4. Negative Mathematics Meme

The participants shared some strong sentiments about how popular culture views mathematics through memes. Of the memes mentioned, two are actually mathematical problems (Sharon, Samantha), which are categorized as neutral memes because they do not impose any feelings about mathematics. Samantha described a system of equations mathematics meme, where each symbol represented some number, and Sharon described a meme that showed a limited perspective of mathematics in the real world. Interestingly, Samantha in her first description, stated that people post these “math quizzes” and ask for help, using social media as a new mathematics space—a site where mathematical knowledge is shared and developed (Walker, 2012). The other two memes that were described illustrated people or characters doing mathematics, and both were characterized with negative mathematical connotations. Samuel described a meme of studying and still failing, which would elicit feelings of anger, defeat, and/or depression. Scott described a meme about a character represented in a state of confusion. Lastly, and most telling, no participant mentioned or recalled any positive mathematics memes.

Marblepond Charter (n = 6). Marblepond’s focus group consisted of all boys. When asked to describe mathematics memes they have seen, Alex alluded to a sentiment Wilma explained earlier: “You know those memes that ask a math question, and they always go viral because everyone’s arguing over the answer.” Agreeing, Akil added, “Yeah, they never reveal the correct answer.” Alfred then joined the conversation asserting, “Sometimes it is like 3 times three divided by 14 plus 5,” describing an order of operations meme similarly depicted in Figure 4.5. Alfred finished his thought by articulating that multiple people are attempting to answer the question—”You see people like 16, 15, 14”—and sometimes it might evolve into a debate.

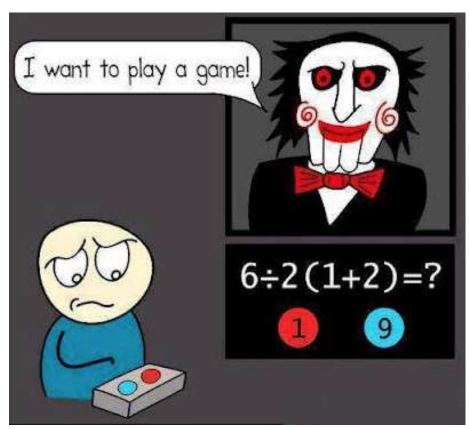


Figure 4.5. Neutral Mathematics Meme

Akil then furthered the conversation by describing another mathematical problem meme. He mentioned a meme having “two cherries plus two cherries plus two cherries equals to thirty and then it has like cherries plus pie equals this." Akil's description seems more aligned to Figure 4.5 presented above, as it is referring to a system of equations, just with different icons.

Marblepond's descriptions of mathematical memes they have witnessed was insightful. Alex's comments from the very beginning were aligned to Wilma's comments from Westpine High School. Alex used the term "viral," which means an image getting shared and passed multiple times through various channels, making it a phenomenon. In order for an image to reach that notoriety, it has to be engaging and compelling so that people keep it propelling throughout. Akil's reaction about revealing the answer was interesting because it suggested the need for a definitive answer, which is telling of a good debate. Alfred's comments about prospective answers also aligns with Wilma's comments from earlier, as it suggests that the available answer options are associated with procedural misconceptions. Alfred's other comment about people's answer choices illustrates that the topic captivates and elicits a lot of different responses and also demonstrates how conversations of mathematics can escalate online. It is interesting because people are responding and explaining, showing that they are active members in this new mathematical environment. Overall the most telling fact from this conversation was that no positive mathematical memes were described.

Fairbourne Prep (n = 5). Fairbourne Prep's focus group included all girls, and it provided a nice contrast to Marblepond's focus group. Though Fairbourne Prep's was small, a lot of information was extracted from our conversation. Francine was very eager to start the conversation and led off with, "I once saw a meme, I'm not sure if this is a meme; it said that MATH stands for mental abuse to humans." Some participants laughed, but not all. Felicia thought for a second and added, "I mean the only thing that I've seen that positively

Figure 4.6. Negative Mathematics Meme

pertains to math is like this thing, ‘me trying to figure out how school is 5 days a week and I only get a 2 day weekend,’ and it’s just this person with a bunch of math in front of them trying to figure it out.” Francesca added, “Or when people do that thing like there are 15 minutes left so that means there’s 3 intervals of 5 minutes … trying to figure out how many minutes they have left of class.” Falyn did not have a particular example of a meme but shared, “It’s like the thing that you see where someone picks a number then add whatever and then you do some trick and they end up with the same number they started with.”

The conversation then steered toward how participants perceived people to look when doing mathematics. Fae started the group off by claiming, “They look like very depressed.” Francesca added, “Yup, kind of portraying the message that math is hard.” Francine overlapping said, “Or like math is terrible.” Francesca concluded with, “Math takes up too much work.”

Francine led the conversation off with an expressive meme. Her meme clearly had a negative connotation and portrayed a message of mathematics being discomforting or torturing. I found it interesting that Felicia, Francesca, and Falyn all went directly after Francine and tried to direct the conversation specifically towards positive examples. All three after Francine were believed to be a positive message about mathematics, but all described an application using mathematics that would be classified as neutral, given the memes did not impose any feelings about mathematics. Therefore, after four memes were described, none seemed to be positive.

Fae’s comments about people looking “depressed” when doing mathematics initiate some critical findings. It is important to note that the look of a person (facial expression) while doing mathematics is as important as the caption, and both impart insightful messages. Students begin to express that memes are indirectly saying that math is hard, math is terrible, and that math takes up to much work.

Moorhall. (n = 7). Moorhall's focus group was one of the largest groups assembled during this exploration, with seven participants. When asked to describe mathematical memes they have been exposed to, participants had a hard time recalling. Maureen finally broke the silence: "There's like one where there is 100 chairs and 20 people eat pizza and the answer was how many times do you travel around the earth's sun?" Immediately Michelle, a focus group mate, asked Maureen what she was talking about. Maureen clarified, "It's not supposed to make sense because math does not make sense, get it." Several students let out an "Oh I get it," followed by laughter and agreement. Figure 4.7 is an example similar to what Maureen was describing.

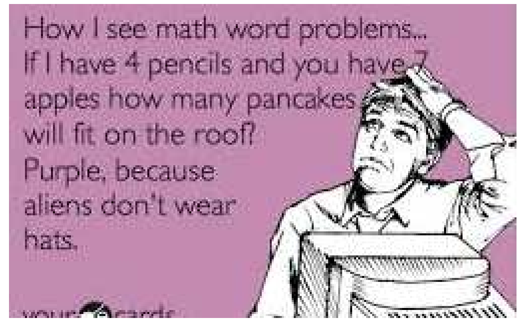


Figure 4.7. Negative Mathematics Meme

Mary then added another example: "People have taken random pictures and there will be a guy with a shopping cart full of hundreds of watermelons and then the caption reads 'this is the people that math problems have warned us about.'"

Though the focus group was only able to recall two memes, their comments were still insightful. First, Maureen's description characterized a negative meme and arguably had the most harmful message. The message that mathematics is not supposed to make sense is one of the most destructive messages and reinforces failure. These beliefs don't manifest overnight or come from one experience; but instead they result from an accumulation of failures or a series of difficulties that student face.

Mary's description would be considered neutral because it does not incite any feeling toward mathematics as a subject but instead is directed at a specific person. Lastly, there were still no positive memes described.

The findings thus far in the chapter have revealed that all the participants reported to having numerous experiences engaging with memes found in popular culture.

Examining the described meme led interesting patterns to emerge, for example, the majority of the participants described neutral memes that characterized a mathematical problem, either orders of operations or systems of equations, which are two fundamental topics in high school mathematics. It also demonstrates that students are transcending the classroom and creating and defining new mathematical spaces. It is interesting that order of operation problem memes and/or system of equations problem memes reach the pinnacle of going viral. It was also acknowledged that there was room for mathematical debates to ensue, which intrigued me to further investigate the comments and responses to these memes. Are users just posting an answer, or are users actually explaining their work and debating mathematics? Also is providing some form of answer helpful? Nevertheless, there seem to be natural educational implications to try using some form or blend of a mathematics application meme for a more traditional educational purpose.

Moreover, there were a variety of negative messages conveyed in the personal memes participants cited. The different classifications of negative memes in students' explanations about mathematics were: math is difficult; math is confusing; math is abuse; and lastly, failing is inevitable, no matter the effort. The saturation of negative mathematics memes is a prevalent finding from participants' descriptions. Watching as students laughed and agreed heavily as memes containing harmful and negative messages about mathematics were described leads me conclude that negative mathematics memes are socially acceptable.

Another interesting finding thus far was that participants were readily able to provide vivid examples of mathematical memes found in popular culture. Of the memes described by all the focus group participants above, 11 were neutral (i.e., describing or explaining an application of mathematics), 7 were negative (i.e., expressing mathematics in a negative light, inciting a negative attitude about mathematics), and none were positive (expressing mathematics in a positive light or inciting a positive attitude about mathematics). Students not being able to describe any positive memes are a very telling fact and speak volumes about not only the purpose but also the necessity of this dissertation. It seems as though Appelbaum's (1995) examination of mathematics has gone unheard.

Definitions from the Individual Meme Activity

Students were presented with nine mathematical referenced memes (an equal number of positive, neutral, and negative) and were asked to place them into groups according to how they perceived their message. The activity also required students to give a short description of why they made their selections (i.e., what made the memes positive, neutral, or negative). Examining the positive, neutral, or negative messages of the IMA, it became apparent that participants had consistency defining ideas of what categorized memes.

Positive meme. The researchers read all positive sections of the student activity sheet from the IMA and developed clear codes that seemed to encompass the description students wrote. Participants' responses ranged from a positive meme providing a motivational aspect, as stated by Willow from Westpine High School, who wrote, "They send out good messages to motivate," to a sense that a positive meme should illustrate the fun part of mathematics, as stated by Matt from Moorhall, who wrote, "These memes are positive in my point of view since all of them are trying to express in a funny way that math is fun, cool, and sometimes satisfying." Akil from Marblepond Charter shared similar sentiments with Willow as he wrote about perseverance, saying, "These images show or send a message that math can be complicated but it's about pushing your way through to reaching your goal." Felicia from Fairbourne Prep stated, "It shows that math isn't totally complicated to a point where no one understands it and how helping each other out allows other to understand math," which illustrates sentiments of perseverance and understanding. Scott from Silvercliff Academy described the feelings of understanding mathematics as he wrote, "It is a satisfying feeling when you learn and get something in math." Alfred from Marblepond Charter agreed and further stated, "Math has a reward when you finish a complicated problem." Lastly, codes were made from either specific words participants used in their descriptions or a synthesized code that describes what participants were trying to articulate. The most common code used to describe positive memes was "understand," which showed up or was described 15 times in students' definitions. The second and third most common used codes were "relatable" with 12 participants and "help" or a synonym with 10 participants. Other codes found to describe positive memes varied from "agree," "motivate," "confident," etc. but were not as common as the other words listed in Table 4.1.

Table 4.1. Common Codes Used to Describe Positive Memes

Code	Frequency (n)	Code	Frequency (n)
Fun	13	Satisfying	2
Relatable	12	Agree	1
Help	10	Persistence	1
Fun	3	Not negative	1
Confident	2	Positive appeal	1
Motivate	2	Upbeat	1
Feel good	2	True	1

*The number of codes in Table 4.1 is greater than 31 (n > 31) because some participants' description described multiple codes. ***

Figure 4.8. Most Common Words Used by Survey Participants to Describe Positive Mathematics Meme

Figure 4.8 is a visual representation of text codes participants described in their student activity sheets. The frequency of each code is signified by the size of the font.

Neutral meme. The researcher used the same process described above to establish clear and concise codes that signify what participants wrote. Participants' responses from the neutral section of the student activity sheet did not differ much in terms of impressions. Participants mainly described neutral memes as jokes. For example, Adam from Marblepond Charter stated that neutral memes “were just funny to me I do not agree, it’s just pictures I would laugh at.” Wilson from Westpine High School echoed those same feeling as he wrote, “It’s neutral because I feel that it doesn’t have a negative or positive thing to do with math, just jokes.” If neutral memes were not taken as jokes, they were mainly seen as opinions that showed no bias. For example, Francesca from Fairbourne Prep affirmed that neutral memes “are funny and relatable messages on math that do not lean on neither positive or negative message.” Sharon from Silvercliff Academy stated, “I say neutral for both of these because they’re not really positive or negative they just show personal opinions.” And Scott from the same school added, “This doesn’t really send a message to the person.” Other than jokes and opinions, some students just labeled neutral memes as relatable events. Willow from Westpine High School said neutral memes explain how “everyone goes through this. It shows how math really is.” The first and second common codes used to describe neutral memes were “No Feeling” and “ No Meaning,” which showed up or was described 12 and 10 times, respectively. The third most commonly used code was “funny,” with 9 participants. Other codes found to describe neutral memes varied from “disagree” and “exaggeration” but were not as common as the other words listed in Table 4.2.

Table 4.2. Common Codes Used to Describe Neutral Memes

Code	Frequency (n)		Code	Frequency (n)
No feeling	12		Complicated	2
No meaning	10		Disagree	2
Funny/jokes	9		Exaggeration	1
Relatable	6		Opinions	1
Do not understand	3			

*The number of codes in Table 4.2 is greater than 31 (n > 31) because some participants’ description described multiple codes. ***

Figure 4.9 is a visual representation of text codes participants described in their student activity sheets. The frequency of each code is signified by the size of the font.

Figure 4.9. Most Common Words Used by Survey Participants to Describe Neutral Mathematics Meme

Negative meme. The researcher used the same process as described above to establish codes that signify not only what participants wrote but also what they implied. Participants' responses from the negative section of the student activity sheet had a variety of perspectives. Participants either mainly described negative memes as images displaying various degrees of frustration about mathematics or images containing some stereotypical imagery and/or message. A negative meme "reminds you of your struggles in math. There is no motive to understand math. They show the frustration of not understanding it," said Willow from Westpine High School. Sean from Silvercliff added that negative memes "make me feel like math sucks and is not essential in life." Interestingly, a lot of participants alluded to stereotypical depictions in their descriptions. For example, Wilson from Westpine High School stated that negative mathematical memes "are giving math a bad name like, it seems that math is something that only a select few know." Francesca from Fairbourne Prep shared those same sentiments: "These memes portray that math is so hard, if not impossible, like only geniuses understand or like math." Felicia from the same focus group added, "Though these are all funny, they still pertain to how most think that the vast majority of people cannot understand mathematics." Akil from Marblepond Charter summed it up by writing, "All of these messages are trying to make people that dislike math be a part of a community that math is complicated and only 'smart people' get it. It's a large discouragement."

Though she did not really describe a feeling, one of the most intriguing responses to negative memes came from Wilma of Westpine High School. She stated that negative memes do not really have a message that she agrees with: “These are feeling(s). Maybe I don’t agree with these because I don’t know those feelings but who am I to tell someone how to feel?” It is interesting because though she does not agree, she knows that others have intense feelings about mathematics and she is respectfully including their voice. The most common code used to describe negative memes was “No one likes math,” with it either showing up or being described 17 times in descriptions. The second and third most common used codes were “Stereotypical views” with 11 participants and “Math is hard” or a synonym with 8 participants. Other codes found to describe negative memes varied from “Give up,” “Math is not important,” and “No one pays attention” but were not as common as the other words listed in Table 4.3.

Table 4.3. Common Codes Used to Describe Negative Memes

Code	Frequency (n)	Code	Frequency (n)
No one likes math	17	Math is not important	5
Stereotype	11	Math is complicated	5
Math is hard	8	Give up	2
No one pays attention	6		

*The number of codes in Table 4.3 is greater than 31 (n > 31) because some participants’ descriptions described multiple codes.***

Figure 4.10 is a visual representation of text codes participants described in their student activity sheets. The frequency of each code is signified by the size of the font.

The data from the IMA (i.e., how participants grouped certain memes and explained why certain memes were positive, neutral, or negative) were also

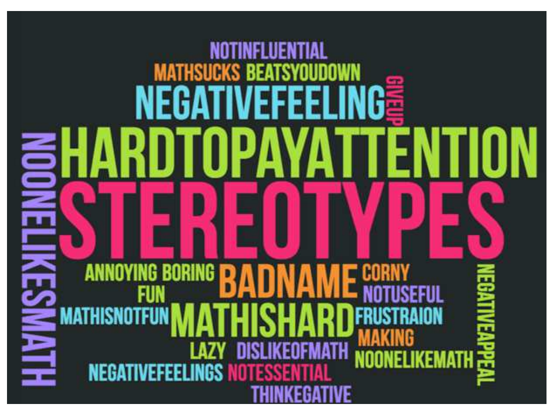


Figure 4.10. Most Common Words Used by Survey Participants to Describe Negative Mathematics Meme

used to ascertain numerical data to investigate to what degree participants agreed with the jurors and begin to determine how participants decided which memes were positive, neutral or negative. All participants' numerical data were collected and assembled into Table 4.4 below. The table illustrates the percentage of thirty-one participants that coded the meme as positive, neutral, or negative. For example meme 2, which was the most definitiveness among participants with 74% of participants agreeing that it is positive. Meme 3 and meme 9 were emphasized to represent memes where the majority perspective of participants differed from the jurors' perspective.

Table 4.4. Percentage of Memes Coded Positive, Neutral, or Negative (n=31)

Meme 1 Juror Rating: Neutral	**Meme 2 Juror Rating: Positive**	**Meme 3 Juror Rating: Negative**	**Meme 4 Juror Rating: Negative**	**Meme 5 Juror Rating: Positive**
Positive	Positive	Positive	Positive	Positive
35.48	74.19	16.13	6.45	41.94
Neutral	Neutral	***Neutral***	Neutral	Neutral
51.61	19.35	***45.16***	22.59	38.71
Negative	Negative	Negative	Negative	Negative
12.90	6.45	38.71	67.74	16.13
Meme 6 Juror Rating: Neutral	**Meme 7 Juror Rating: Positive**	**Meme 8 Juror Rating: Negative**	**Meme 9 Juror Rating: Neutral**	
Positive	Positive	Positive	Positive	
25.81	41.94	16.13	12.90	
Neutral	Neutral	Neutral	Neutral	
48.39	29.03	22.58	32.26	
Negative	Negative	Negative	***Negative***	
25.81	25.81	61.29	***54.84***	

As Table 4.4 shows, there was no one meme that was undoubtedly considered positive, negative, or neutral. However, nearly 75% of the participants coded meme 2 as positive, which happened to be the most agreed upon meme (see Figure 4.11). Meme 4 and meme 8 were a little less resolute, with only 68% and 61% of participants coding them as negative, respectively. Meme 9 and meme 1 had barely over 50% agreement for being negative and neutral, respectively.

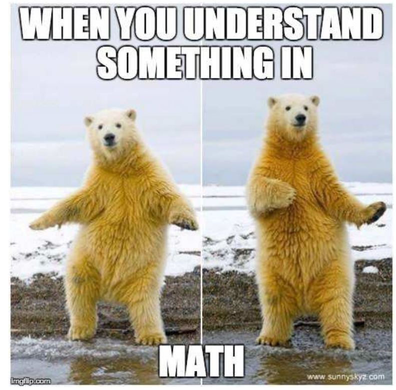


Figure 4.11. Meme 2

Even though participants could not agree on one meme definitively, the majority perspective did align with the jurors’ perspective except for two memes (meme 3, meme 9). Jurors coded meme 3 as negative, and the majority vote from the participants coded it as neutral. As shown in Figure 4.12, Meme 3 reads, “Me in math class” and shows a picture of Homer Simpson, a relatively dimwitted character on the Simpson series, asking the question, “Can you repeat the part of the stuff when you said all about the things?” Collectively the meme’s message is about being confused in mathematics class. Homer’s body language is positive, shown by a smile on his face, and by asking a question, he’s at least trying to be attentive and understand and not giving up. “He’s asking a question,” wrote Samuel from Silvercliff Academy on his student activity sheet for the Individual Meme Activity.

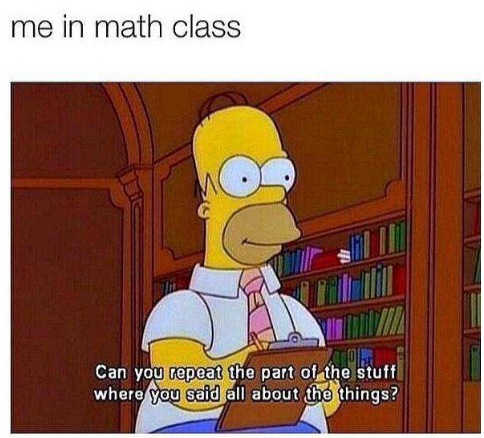


Figure 4.12. Meme 3

As shown in Figure 4.13, Meme 9 illustrates Gary Cole playing Bill Lumbergh, a character from the movie *Office Space*. It reads, “If math would grow up and solve its own problems, that’d be great.” The jurors coded meme 9 as neutral, while the majority of participants coded it as negative. Though the meme is asking mathematics to solve its own problems, it is not

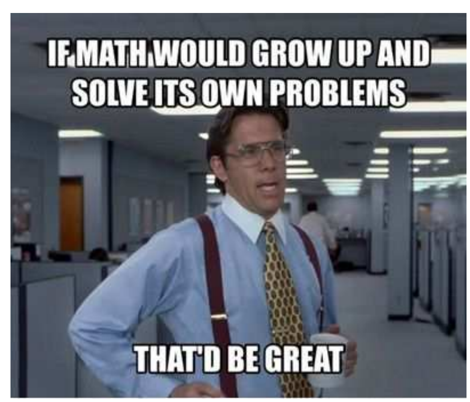


Figure 4.13. Meme 9

saying anything objective about mathematics, and additionally problem solving is a component of mathematics. However, the body language of Bill Lumbergh could be perceived as annoyed, and asking mathematics to solve its own problem can be perceived as irritation.

In summary, participants defined positive meme messages as those that help or show understanding of mathematics. Participants defined neutral mathematics memes as memes with no feeling or meaning toward mathematics or some type of joke. Lastly, participants defined negative memes as memes that illustrate a hate of mathematics. The main difference between participants' and jurors' definitions were that participants were really explicit in teasing out certain messages, while jurors kept their definitions basic to encompass a range of positive, neutral, and negative messages.

Messages from Meme Inventory

Furthermore, examining all transcripts and comparing responses across all focus groups revealed several messages about mathematics that participants found in memes. In their descriptions, participants articulated different messages they had received about mathematics, and though messages seem to naturally partition into separate groups, they are not. The messages have distinct features but are interconnected and illustrate a lack of understanding of mathematics. The messages are displayed below in a systematic way to help illustrate the associations.

Math is complicated; too hard to understand. Throughout the focus groups, various participants directly and indirectly stated that mathematics is complicated and something that people in general do not understand. Many students come into mathematics classrooms with valid feelings that make them unhappy doing mathematics (Willis, 2010). Moreover, Wilma from Westpine High school summarized our discussion, stating, “People do not like math or understand it,” which is a strong sentiment. Participants also discussed having no intervention for fast pacing or advanced curriculum.

Without properly identifying intervention strategies, students often find themselves “lost” and scared, which was further explained by Silvercliff Academy’s focus group:

> Sean: Like you can’t miss a day in geometry. You learn something every day.
>
> Samuel: Literally. They have a new topic.
>
> Samuel: Number eight [meme 8] where it’s like you know that awesome feeling when you finally understand math and then it’s the Obama face and he’s like, me neither.

Furthermore, Sean added that he found mathematics to be difficult due to the sequence. He asserted that the progression of content and the lack of connections add to lack of comprehension in mathematics.

> Sean: Yeah, it’s like based on the thing that you just learned, like right now we’re learning functions on a graph. So first we started with like slope and stuff, and now we’re advancing in quadratic and I’m like I thought I understood this. Now it’s like really complicated…. At first they make it seem easy and then they make it more complicated.

Probing further into whether this was a good or bad thing, Sean added:

> Sean: Yeah, just throw it all at us at once. Because now you’re getting us confused, you know?

Samuel agreed and added, “That’s why all memes are making fun of math,” to close that segment of the conversation.

An analysis of Sean’s and Samuel’s comments, specifically in the above statements, revealed that the crux of their confusion came from not understanding the association between mathematical topics. This could be problematic because of mathematics’ cumulative nature. Therefore, if the connection from topic to topic is not achieved, it could create huge gaps of knowledge. Conceptual knowledge will continue to be a dilemma because the building blocks from the previous mathematical topic are not there.

Effort. If you came into mathematics expecting it to be complicated, how much energy will you exert? Perspectives are generally formed through experiences and can be affected by preconceived notions. For example, the participants above explained that mathematics is complicated and not easily understood, so that they have a preconceived notion of mathematics moving forward.

Sean from Silvercliff Academy additionally explained:

> Sean: Like in eighth grade, I actually loved math. Like I found it so easy that all I had to do was just write it down. But now it's like a lot more complicated and you have to use your memory and like ten different things.—

When I asked Sean to clarify, he acknowledged that he did not previously have to try and now he has to. He added, "Yeah. But before it was just like do 20 questions really fast and you're done."

It became clear that Sean attributed his love for mathematics to the effort he exerted. He stated that he loved mathematics because it was "easy" to him, and he applied little if any effort at one point. Now, mathematics is requiring him to make an attempt, and his love for mathematics is decreasing. What is interesting about that is he sees effort as a bad thing, which is a defining characteristic of a fixed mindset (Boaler, 2013; Dweck, 2010). The impression is that if you have the "ability," you should not need to try hard, and if you need try hard, that is a sign that you do not have the ability. Sean demonstrates a sense of displacement as stated by Riegle-Crumb (2006) because he got into a habit of not trying hard in mathematics, and now that an effort is needed, he is having difficulty doing so.

The ability to ask questions was found to be an additional sub-theme that emerged from the data coded as "effort." Do students ask questions during mathematics class? An abundance of participants agreed with the message behind meme #3 (Figure 4.11), stating that is how they were in mathematics class. Not grasping concepts in mathematics can be a demoralizing thing, and if it happens, what can one do? Participants acknowledged that there were times they did not understand what was happening in mathematics class, and they described two avenues they executed when this occurred: ask questions in class or stay confused.

Felicia from Fairbourne Prep ended with: “For those who have expectations that math will be hard, and for those who are going into higher levels, they could also have the expectation I’m going to suck so they’re just not going to put in their effort as much as they should.”

Ask questions. When deciding to ask a question, participants described feeling disconnected and not know specifically what to ask. For example, Samuel from Silvercliff Academy agreed with three meme stating, “This is me in math class.” Samuel further mentioned, “I always ask questions. It’s like I never understand it, but I’m still asking questions.” Samuel went on to describe that when he is confused about a topic, he is not quite able to articulate where he got confused or how to describe his thinking, which is frustrating for his teacher. He admitted that most of the times he is confused, he is not paying attention but said he still asks a question. Samuel’s closing remarks were two-fold: it is clear that Samuel knows asking questions is a good thing and applauds himself for making the attempt, but HE does not fully understand the purpose of asking questions. It seems as though Samuel ask questions for their own sake because he admits to not gaining any clarity after his questions are answered.

Do not ask questions. Interestingly, enough some participants elected to stay confused rather than ask questions in mathematics class. For example, Felicia from Fairbourne Prep explained, “I can relate with [meme 3] sometimes because if the teacher is going a little bit fast and I’m just like looking at her like.” Francesca jokingly added, “Yeah, just like nodding your head, like okay!” At that moment, Felicia decided to live with her confusion rather than asking a question in class, which is one of the most detrimental things she can do to her learning. Though Francesca was jesting, nodding is a physical cue of understanding. So though Felicia was confused, she wanted to signify that she understood what was going on.

Moreover, Michelle and Mike from Moorhall shared a similar experience to Felicia's in their mathematics class.

> Michelle: Yeah stuff is just on your mind. You leave math class and you're like damn! I don't know anything that just happened.
>
> Mike Facts, I go home like, yo, what's the homework?' I look at it like, what is this…. I be scared.

Michelle went on to explain that she could repeat key phrases and words in class but still not have a strong grasp on the material. Mike added that he felt secure in class but, as described above, when he got home, he felt a sense of vagueness. He had hoped the material would continue to make sense when he was alone doing homework.

Lastly, Alfred from Marblepond Prep explained, "Usually when we copy notes I usually see a whole bunch of numbers on the board and like I don't even know who did it…. I write them down I'm like oh so what did we just do." Alfred dutifully takes notes but does not ask questions with the hopeful impression that just copying notes will help him retain and understand. Knowledge is not acquired by solely copying notes; students need to be actively engaged.

But all these experiences happened, and not one participant talked about raising their hand, stopping class, and asking a question. Each participant described letting class continue without them grasping the content. Above Mike alluded to being scared not understanding something and in fact it could be an anxious time. This, too, is a characteristic of a fixed mindset; oftentimes students have questions but are to afraid to ask because they are afraid to look dumb (Boaler, 2013; Dweck, 2010).

Uselessness. Inevitably when dealing with a subject that has a preconceived notion of being complicated with minimal student effort and the stigma of asking questions, one starts to wonder what the purpose is. Participants felt like mathematics is so abstract to their daily lives, and often asked the question, “When will we ever use this?” Many participants claim that they have yet to encounter mathematics outside school, and most feel like mathematics is only relevant to a small amount of career fields. For example, Michelle from Moorhall expressed, “It’s [math] useless.” When asked to clarify further, she stated, “That’s what they say [about Math].” Mike, a fellow focus group mate, affirmed, “Yeah, that’s what everybody says…. Like we don’t need to use it when we are older.”

More participants began to join the conversation.

> Melissa: Like some of the stuff we learn now, we are never going to use in our life.
>
> Mary: And sometimes they will make fun of the way teachers say that we are going to need it for our life, but so many teachers have said it to us that we just take it as a joke now.
>
> Mike: Yeah, like people say you need the Quadratic formula.
>
> Melissa: Some people do need it; it depends on what you want.

Mike then went on to support his initial claim.

> Mike: Yeah but most people don’t need it when you think about it. All right, think about it, if you’re working in a hospital. Then you would need it because you’ll need to know the amount of medicine you put in, because you can put in the wrong amount and that person could die…. But say you’re doing clothing; you don’t really need to know it, you’re just designing something.

Mark interjected with an opposing thought, “Nah, if you’re rich you’re going to need it ‘cause you are going to need to know how to manage your money.”

I found this exchange among participants especially interesting because the conversation was solely happening among them, highlighting a number of misconceptions. Mike’s, Melissa’s, and Mary’s initial plight was about the actual application of mathematics and its usefulness. Mary admitted that teachers and adults have said that “you will need it,” and there were natural attempts to declare the importance of mathematics, but those are now exhausted. The question is: Were the attempts meaningful, because ultimately there is a lack of understanding mathematics and its use or real-life applications. Another noteworthy point is that Mark attempted to illustrate the practicality of mathematics by using money as an example. Money tended to be the marquee answer for students when discussing mathematics' usefulness, which is not perverse but is trivial. There have been a number of studies showing that students comprehend mathematics more when they get to witness its real-life application, not some frivolous application in a word problem in a textbook (Resnick, 1987; Saxe, 1988; Taylor, 2006; Willis, 2010). Willis (2010) also states that capturing students' imaginations is the key to expanding their interest. Rather than allowing students to think of mathematics as an isolated subject, show them the direct connections to encourage its value.

Lastly, it was interesting to note Mike's explanation of where he feels the quadratic formula is useful and where it is not. He described a simulation where a doctor needs the quadratic formula for their patients in a life-or-death scenario and a clothing designer who does not need it. The overall irony is that doctors rarely, if at all, use the quadratic formula when distributing medicine, but clothing designers occasionally utilize its application properties when manufacturing clothes. Often times students may use extreme examples to rationalize the significance of mathematics in the real world but are such examples applicable to their experience with mathematics? Though some examples may satisfy the objective, I would argue that students are not fully contextualizing mathematical applications because there are relevant examples within their context that also may satisfy and may be more beneficial in emphasizing those specific examples for tangibility. I do, however, appreciate his passion in using a life-or-death situation because it may symbolize that he knows there is an importance to it, but he does not full understand it.

Math is not fun. Examining the emerging themes above, it is reasonable that "math is not fun" was also an emerging theme. Boaler (2008) states, "Among students who experience traditional math classes, one of the biggest complaints is that the classes are always the same. The monotony causes disaffection; it also means that students only learn to work as they have in class—using procedures that have just been shown to them" (p. 158), which seamlessly describes an environment that is not fun. Students are routinely asked to memorize procedures and are told to make conceptual connections without any explanation. The curriculum rarely primes student interest.

When recalling his experiences in mathematics class, Sean from Silvercliff Academy explained:

> No, I remember one day she [Ms. Dailey] did this new thing where like I don't remember what it was, but it was like something you subtract five from a number and then you divide it by five, and then it gives you another multiple. And she's like, isn't this fun? And then it was quiet in that room.

Sean went on to add that he did not see the point of mathematics. Unfortunately for him, this is an uninteresting application of mathematics that reinforces procedural knowledge and procedural skills; if you are bad at it, it would not make sense to you.

Samuel, a focus group mate, also shared, "I feel like that's what all teachers try to do, right? When they're in math, they try to make it like so cool and like fun and I'm just like, it's not fun." He went on to explain that mathematics is not supposed to be fun, and that you are just supposed to work. This brings up an interesting point: What definition or expectations do students have when they hear "math is fun"? Does Samuel expect mathematics to be fun in the same sense of an amusement park, or does he mean he enjoys being able to solve the problems? The fact of the matter is that fun is relative to the interpreter, and a narrow definition can distort the level of enjoyment. Nevertheless, in his experience, mathematics has yet to be seen as meaningful. Subsequently, after Samuel's comment, Sean alleged that meme number 5 did not make sense. He stated, "I didn't know if it was a positive one or bad, like is it actually teaching us that, how to do math or is this just like making fun of math because it doesn't make any sense?" I felt as though he stated this an example of Samuel's earlier comment that mathematics is not cool or fun. Samantha and Scott immediately responded to Sean's remark and discussed their interpretation of meme number 5.

Scott started off by saying, "No, I said, it [Meme 5] was positive because it's telling you that you people are thinking out of the box, showing different ways to learn about math. Samantha added, "Right the X squared, it has the arms going like that [gestures]. It has the arms going like that it's imitating like parabolas."

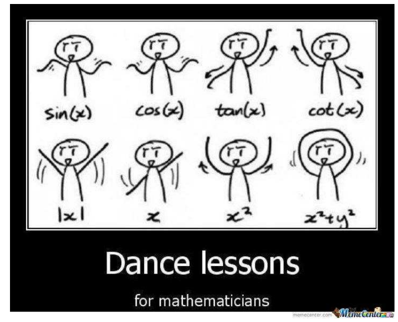


Figure 4.14. Meme 5

The importance of this dialogue demonstrates Samantha and Scott's recognition of an attempt to associate mathematics further than algorithms. In this particular sense, mathematics isn't fun, but it is useful and helps students construct meaning.

Stereotypical imagery. Furthermore, examining all the previous factors, it is no wonder that many messages were based on stereotypical thinking. It seems as though memes were created to express the visual imagery for the common mathematical stereotypes or misconceptions that exist (i.e., it is acceptable to be bad at mathematics because most people are; people do not really use mathematics outside of school; you have to be a nerd to be good at mathematics, etc.). When discussing common characteristics portrayed in memes about people who are good at mathematics, nearly all focus groups agreed with Falyn from Fairbourne Prep, who stated, "I feel like they are nerdy." I asked her to clarify what "nerdy" exemplifies and on the top of her list were glasses and braces. Wilma and Wakanda from Westpine High School added:

Wakanda: … it's kind of making fun of people with glasses and who look a certain way, look like they are nerds.

Wilma: Yeah, they are portrayed to have glasses.

When asked if either believed it to be true, Wakanda replied, “In like television and like social media yeah but in reality no.” This example illustrates their awareness of a “math look” even though they know it not to be true.

Surprisingly, participants also indicated ethnicity, such as being “*Asian*” or “*Indian*”, to be a common trait of people who do well in mathematics. Wilson from Westpine High School suggested that the media, specifically television, seems to encourage the idea that certain ethnicities are mathematically inclined. He voiced, “You see it a lot on TV, people think because they’re smart, Asian they’re smart.” Willow added, “And Indian people are good at science.”

Additionally, when asked whether or not they truly believed the stereotype, most participants rejected the thought. Probing further, participants alluded to media as the driving force behind such stereotypical thinking, stating that the common imagery is implanted in their minds.

When inquiring about stereotypes, students from Fairbourne Prep’s focus group provided an interesting perspective about the stereotypical view of Asians in mathematics:

> Falyn: And even that’s not a good stereotype because the stereotype is that Asians do not have a social life.
>
> Francine: That’s true and they just focus mainly on their work.
>
> Francesca: It also pressures you because what if you are not doing well in math class and it’s like well you’re supposed to do well.

Falyn abstractly introduced the idea of good and bad stereotypes (i.e., beliefs that attribute a favorable or non-favorable characteristic). In Falyn’s case, though being Asian would seem “good” because one would be perceived as smart, contrarily it is negative because there is no social life. Analyzing her statement further, she attributed Asians to be smart not because of their *innate* ability, but because of the time and effort they put in. Additionally, Francesca introduced the idea of the unconscious pressure associated with stereotypes that might cause individuals to underperform. Though this might be perceived as stereotype threat, it is not. Stereotype threat refers to negative stereotypical pressures, and Francesca was pointing out the negative pressure associated with a positive stereotype (Steele & Aronson, 1995). This pressure is disruptive because it may lead to excessive attention to self and performance (Tagler, 2012). In Francesca's case, Hua-Yu Sebastian Cherng, states that the stereotypes Asian students face can change how they perceive support overall and alter their own expectations (Cherng & Liu, 2017).

Sense of accomplishment. Not all messages that arose were negative. There were an overwhelming amount of student participants that disagreed with meme number 1's underlying message as well as consented with the message of meme number 2. Scott from Silvercliff Academy said that most of his teachers tell him not to use a pen in mathematics because he is likely to make a mistake. He explained, though he understands the practicality of their suggestions, he has confidence in himself. Scott stated, "…but what about confidence? Or like in Mexican, you have so much *huevos* (machismo) … yeah, he has such confidence and you know, if you know you're not going to make a mistake, why use a pencil when you can use a pen?" Participants not only described the confidence when writing in pen; they also expressed confidence when they got a problem right or understood mathematics. When recalling his experiences in geometry class, Sean explained that meme 2 (Figure 4.11) was extremely relevant. "'Cause that's how I feel sometimes, like in geometry class, it takes like two days to finally understand it and then I'm happy, you know, you finally understand."

Francesca also acknowledged and affirmed that message in meme number 2:

> I don't start dancing, well in my head I do because it's really like math is usually kind of hard. I think when you are in a class that's supposed to challenge you the whole time … there's nothing where its really like history where you are just reading and you understand and are just gaining knowledge … especially in Fairbourne Prep it is more like problem solving on your own so its challenging throughout the whole way. So once you get it, it feels good.

Both Sean's and Francesca's responses are representative of the other comments received and highlight the fact that mathematics gives a feeling of accomplishment that no other subject provides. It also confirms that students actually want to understand and be successful in mathematics. Francesca's comments emphasize that mathematics is unlike any other subject, and one of the major distinctions is its cumulative nature. For example, in English class, a student can rebound from a bad experience when the class starts a new book or a new chapter; there are several entry points to receive a "clean slate." But in mathematics, a student's success is directly connected to his or her previous year's experience.

In conclusion, these findings suggest that not only have participants observed numerous memes about mathematics in popular culture, but they are also receiving messages from those memes. One investigation focused on participants' explaining the experiences they could recall with mathematical memes, examining the underlying messages. Uniformly, all memes described that were not mathematical problems had a negative message about mathematics. From the variety of descriptions, one conclusion that can be drawn is that negative mathematics memes are easily found and easily replicable. More surprising was the fact that not one participant was able to recall a positive mathematics meme, which conversely reinforces that negative messages are socially acceptable. Next, participants got to constitute their definitions of positive, neutral, negative using memes from the meme inventory. They collectively defined positive meme messages as uplifting and showing an understanding of mathematics, neutral memes as a joke about mathematics, and negative meme messages as discouragement to mathematics and a lot of stereotypical references. Overall participants and juror disagreed on the messages on two memes [Meme 3, Meme 9]. The jurors originally coded meme 3 as negative and meme 9 as neutral but the majority of participants defined meme 3 as neutral and meme 9 as negative. This finding suggests there are differences on how adults define neutral and negative memes, and further, that what young people view as negative may not be seen this way by adults, and vice versa.

After examining the transcripts, six major themes arose: stereotypical views of mathematics, mathematics is too complicated, effort in mathematics, mathematics is useless, mathematics is not fun, and sense of accomplishment. Characterizing participants' experiences, there is a belief system [might not be the primary] of mathematics and how it is supposed to be experienced that has been adopted.

Mathematics being described as "complicated", "useless" and "not fun" is not new a phenomenon but instead are deep rooted descriptions used long ago (Appelbaum, 1995; Latterell & Wilson, 2004; Leder, 1992). Students' experiences with mathematics memes of today are cultivating messages of mathematics from long ago. Memes become a new vehicle for age-old mathematical messages and stereotypes.

Many have become content with this definition and way of doing mathematics and have developed these as an expectation. Overall, this perception of mathematics is limited, and this stereotypical thinking of mathematics is one of the most self-destructive ideas in America today. The messages that participants specified they were receiving from memes allude to the age-old conversation: Do people need to know mathematics? The participant excerpts above are direct examples of what Boaler and Greeno (2000) described as a limited interpretation of mathematics and highlight an aspect further than the way mathematics is taught and further than lack of exposure to real-life applications. There was an undertone of the benightedness of mathematics. Though participants use mathematics as a tool, there is a general obscurity about the abstractness of mathematics. People can add and subtract or do procedural mathematics, but the essence of mathematics is lost; the purpose is gone. I think most people are dimly aware of just how vast mathematics is and how many subfields are contained within it. This obscurity has led to a limited understanding of what math is, why it is needed, and how to excel at it.

Answers to those questions are dissertations on their own, but I wondered if the participants could begin to answer them, or was mathematics just about getting good grades? My observations have led me to believe that many students assign little importance to the instrumental value of mathematics learning. Mathematics is not about numbers or about solving equations; equations are merely a tool that assists understanding in a particular context. Though mathematics is the study of structures (Gowers, Barrow-Green, & Leader, 2010) and is constrained by the laws of logic, it is creative. The association between equations and the Cartesian plane is a perfect example of how mathematics mends all three. Mathematics will help people understand the world around because it is in almost every facet of our lives (purchasing, cooking, banking, scheduling, sports, medicine, etc.). It is also the language of science, engineering, architecture, business, Internet, fashion design, aeronautics, and astronautics, as shown by the popular film, *Hidden Figures*. Last but not least, mathematics provides access. A once historically segregated field with many barriers is now more inclusive (Martin, 2000). Malloy (2002) states, “See that mathematics can expand and deepen the democratic possibilities” (p. 23). With the advancement of technology, mathematics education should prepare students “with the tools of engaged and critical public participation in a diverse, heterogeneous democracy” (Lipman, 2006, p. 112).

Research Question 2

> *If messages about mathematics from memes in popular culture are received by students, how are they internalized?*

The researcher decided to examine internalization of messages in multiple ways: through an analysis of transcripts selecting common themes, through participants’ descriptions of their creation of a mathematical meme and the comments they would leave associated with a specific meme, as well as participants' testimony on whether they have or will ever share, post, "like" any mathematical memes.

Despite a teacher's vision, efforts, and intentions, several complicating factors steer students' personal beliefs and could bring about a different reality. To examine the reality of the participants in this study, participants were asked, "If you had to create a mathematical meme, what would you create?" Participants were given free rein to describe how they would create a mathematical meme. The descriptions of images were not evaluated on creativity but were analyzed more for their symbolic representations and visual images to be read as "text" (Fiske, 1989; Kress & Van Leeuwen, 1996). There are varying degrees of interpretation, which are linked to variables such as age and gender; nevertheless, the participants' meme descriptions allow researchers to draw detailed observations of their thoughts and beliefs and assist in explaining whether or not messages are being internalized. Many participants articulated this as fun because they got to share their mathematics experience with each other through their own lens. Before students began describing their memes at Silvercliff Academy's focus group, the students described the aspects of an effective meme. Scott explained that images are not only the captivating component of a meme, but they also hold a symbolic message. He stated, "The picture pretty much like shows the expression, like if it's just plain words without a picture, it just feels like, oh, he's just saying a statement. But if it shows a picture, it shows the emotion." Samantha added that captions hold the true meaning of the meme; she stated, "[captions] have a specific message or messages which you're trying to relate to or talk about." Both Samantha and Scott illustrate that creating a meme is an autocratic process, and interestingly, most participants, if not all, said something along the lines of what Sean expressed: "If I'm going to make a meme, I'm going to make it relate to me and how I feel about math."

Rather than express all hypothetical meme creations, I have chosen to convey a representative sample. Alfred, a participant from Marblepond Charter, stated, "I would probably look at someone's facial expression and [the caption would read] 'when you get a question that is never taught in the classroom.'" Similarly, Felicia from Fairbourne Prep articulated her meme as "it would probably be like those things where people step on a rake and it hits you in the face…. That's me going through math or trying to understand math." Samuel from Silvercliff Academy's focus group got creative when designing his hypothetical meme. He stated:

> I'll put the '*when you're taking the quiz versus after you're done taking the quiz.'* Then I'll just take the Mr. Krabs with the weary effect. And then after I'm going to show a test with a zero on it, and then the Arthur hand.

Samuel went on to clarify:

> But like sometimes it [geometry] will make sense … like you know sometimes you have sparks, where you just, oh, I understand that or, oh my God, like '*I finally get it!'*, after trying so hard to get it. And then like the next day, it's just like a brand new subject and you're confused again.

Francesca, a participant from Fairbourne Prep's focus group, stated, "I don't know this year hasn't been so hard for me. So I don't think I wouldn't make a math is hard meme. It will probably be a when you understand math type of meme." Interestingly, Francesca's meme description was the only positive description of all participants, and she attributed it to having a positive year in mathematics.

These images are aligned to the participants' experiences and ultimately align to who they are. Weber and Mitchell (1996) stated, "While images always maintain some connection to people, places, things, or events, their generative potential in a sense gives them a life of their own, so that we not only create images, but are also shaped by them" (p. 305). The memes also depict mathematics through subliminal messages, which are not easily captured. Nevertheless, the overwhelming majority of the descriptions were negative, which was not surprising but revealed a traditionally negative culture convoluted with stereotypical views (Mensah, 2011).

Participants were not only asked what mathematics memes they would create but also were questioned about their social practicing around specific mathematics memes (i.e., like, comment, share, etc.). Soliciting information about their practices of "commenting," "liking," and "sharing" would give insight on their affiliation and positioning on negative mathematics messages on social media. My observations indicate that students generally discuss their social media practices in the same manner: laughter, agreement, and sharing! For example, Michelle explained while looking at negative mathematics memes on social media, she is sure to find comments such as "this is Facts!" Melissa sees comments such as "Oh my god this is so true." Mike added that everybody will start tagging his or her friends, which is another form of sharing. Mary included that she mostly would see the laughing crying emoji. Francine from Fairbourne Prep stated that she sees comments like "that's how I feel." Furthermore, Willow explained, "Most of the time stuff like that, everyone agrees. Nobody will disagree, everyone will just agree." Probing her further, she affirmed, "I would not comment, but I would share it."

My findings thus far not only demonstrate an overwhelming amount of negative mathematics meme creations but also agreement with those negative messages. The examples of memes and their respective comments illustrate a culture of social acceptance among young people today. Willow's noteworthy comment, "nobody will disagree," is extremely telling and calls attention to the established online culture. Negative meme messages are met with acceptance because they do not challenge the conceptions of what the larger culture (popular culture) believes about mathematics. Another interesting note is that Willow declared that she would not comment on a negative mathematics meme but share. According to Kim and Yang (2017), sharing a negative meme takes a greater level of commitment. Sharing a post illustrates a connection to the meme's message and not only creates a wider dialogue, but drives it further as well. But perhaps the most shocking finding thus far is that over 80% of negative meme creations came from students with high self-perceived mathematics ability. This illustrates the socialization of mathematics in the larger culture; even students who are believed to have high reverence for mathematics disregard it and create memes that display mathematical contempt.

Furthermore, not only were there an assortment of negative creations, but there was also a centralized theme of who is affected by negative messages. A substantial amount of data indicate that student participants believed negative messages are not uniformly received and that students with strong mathematics abilities are less susceptible to negative mathematics messages. For example, Willow from Westpine affirmed that for "some people math is easy for them and for other people math is hard for them, they would have different perception of them [memes]." Francine from Fairbourne Prep's focus group also acknowledged this belief, adding, "No my sister likes math, and she's like good at it so I don't think it's going to affect her like that."

When probing further for clarification, multiple students from different focus groups commented:

> Alfred: If someone was really good at math, then they will probably have a deep debate about these kinds of memes.
>
> Antwon: Yeah. Like people who leave school, who really like math and they actually do it for fun, they might see this and be serious.

It is important to note here that Antwon and Alfred only consider "good" mathematics students to be concerned and affected by a negative meme portrayal. Moreover, as the focus group continued, Antwon stated, "It depends on who you [are] showing it to, probably someone who struggles with it [mathematics] might think something different." Comparatively, Antwon slightly contradicted himself. Earlier he stated that only "good" mathematics students would be concerned or affected, but here he was associating negative memes' relatedness with struggling students.

In a like manner, Michelle from Moorhall stated, "Some people are good at math and some people are bad, some cannot relate and some of them can" as a catchall statement. But here she was still attributing a student's perception and relatedness to a student's ability to perform at mathematics.

Another compelling piece of evidence happened when facilitating the Silvercliff Academy focus group, where a debate ensued on this topic. The deliberation began with students generally agreeing with the claim that students' mathematics ability affects how a student perceives messages. For example, Sharon and Samuel declared:

> Sharon: People have different understanding towards math
>
> Samuel: It also depends how your math skills, like if you're good at math … yeah, actually it's true 'cause like as long as you understand math, then you're going to probably relate to at least one of these [positive memes].
>
> Sharon: It probably doesn't have to do anything with like ethnicity or race.
>
> Steven: Or gender.

It is important to note here that students were reflecting on their own thoughts and coming to their own understandings around the claim. To summarize, students articulated that positive mathematics experience would relate to positive memes. Conversely, negative mathematics experience would relate to negative memes. This thinking is decisive and leaves little room for mathematical experience to conjoin with present mathematics experiences because the implication here is that there is one overall mathematics experience. Thinking about it further, Samuel interjected and shifted his opinion:

> Samuel: There are plenty people that are amazing at math, like my dad, he's really good at math and although he didn't like it at all when he was in school.

Samuel's evaluation of his father's mathematical experience helped him become more receptive to the idea that sentiments and ability are two different characteristics, and, though they may influence one another sometimes, it is not always the case. Samuel's new perspective also furthered the conversation and allowed new ideas to cultivate. Susan and Sharon added:

> Susan: I don't know, maybe it depends on your background, like your family. If they're good at math, then maybe you would think you're good at math.
>
> Steven: Yeah your surroundings.
>
> Sharon: Yeah, because like, depending on your family … you know, some families, they teach their kids math at a young age, so when they grow older their understanding is better.

Given this last conversation, Susan, Steven, and Sharon all began to identify other attributes that influence perception and/or ability. Nevertheless, all three came to the conclusion that they were not assessing matters holistically, and it seems that Sharon and Steven had changed their thoughts from their initial statements. Ultimately, Samantha concluded that interpretation of memes is complex: "It's just like the way your brain functions … everybody can have a different way of explaining things." Mike from Moorhall's focus group additionally stated, "Yeah some of the things [memes] might be [interpreted] the same but everybody got their own mind so they could look at this and they could take it in a different way."

In general, young women made up 48% of the participants in the study, and no matter the focus group, most commonly referenced meme #7 as stereotypical and extremely offensive. In particular students at Fairbourne Prep, an all girls school, had a lot to say.

Figure 4.15. Meme 7

> Falyn: I know it's like an Indian kid,
>
> Francesca: With glasses.
>
> Falyn: He's like the little nerdy kid that couldn't get a girl.

Several of the participants began to laugh, and then Falyn began to pivot the conversation to an underlying message as she stated, “But it’s also saying like that girls aren’t good at math, which is a problem in the math industry world.” Felicia then added her thoughts from another perspective: “I don’t think this would be interpreted the same between the genders.” Francesca added, “Yeah I think for example a guy would kind of just laugh at number 7 as opposed to us saying this isn’t really OK in a way.” Falyn then concluded, “I think it’s influential well not in a good way but like it has an impact.”

Furthermore, Moorhall’s focus group also made some notable commentary about meme 7’s stereotypical impression and implications. Michelle explicitly said, “This is racist.” Contrary to Francesca’s thoughts, Mike added, “Someone can take it as insult.” Though he did not definitively say who, he certainly was not laughing and thought about the serious inference behind this meme. Maureen and Michelle summarized, though the intention seemed positive, there are sure to be alternative perspectives. Maureen asserted, “Because they’re [Indians] typically smart or they’re stereotypically smart.” And Michelle concluded, “So they might take it as offensive.”

In conclusion, these findings suggest that memes can assist with the assimilation of negative messages about mathematics. Based on their hypothetical math meme creations and previous social media practices, it does appear that the students have participated in a socialization process of publically shaming mathematics and have internalized the negative messages. My sample contained approximately 80% of students who self-identified as above average mathematics students, but approximately 80% of students created a negative meme, and all agreed that they have engaged in negative online practices such as sharing negative memes, “liking” negative memes, and putting a “joking” comment beneath a negative meme. Though students might not associate these activities as mathematical in nature, it is a response to the explicit and implicit messages they are receiving about mathematics manifested in online practices and meme format. This process demonstrates not only enculturation, the assimilation of an existing tradition (i.e., being bad at mathematics is socially acceptable), but also acculturation, inter-culturally borrowing to create a new or blended culture (i.e., creating memes to express being bad at mathematics).

According to Gail FitzSimons (2002), mathematics memes [public images] reflect both the cognitive and affective domain concerning knowledge, values, beliefs, attitudes, and emotions. She expresses that

> a very strong influence on the public image of mathematics comes from the experience of formal mathematics education … [and] other influences such as stereotypes reinforced by popular media, or personal expectations conveyed explicitly and implicitly by significant others such as peers and close relatives. (pp. 44-45)

Another finding suggest that students believe their mathematical ability level dictates not only their perceptions of a meme's message but also their susceptibility level. Students believe that lower mathematically performing students are more influenced by negative messages about mathematics and conversely higher mathematically performing students are less influenced by negative messages. There is no empirical evidence to support this claim and is an entirely different dissertation on its own. However, it seems as though students have suggested that higher ability students are less affected by societal messages about mathematics.

Research Question 3

> *How are associated messages from memes influencing the construction of mathematics identity?*

The primary data source to answer research question 3 came from transcripts and field notes, or other general aspects, for instance, how participants explained what they believe to be the purpose of mathematical memes. The researchers also focused on particular questions, such as "If you had a little brother or sister, would you let them look at these memes?" and examined participants' justifications.

Overall, when comparing responses across all focus groups, the consensus was that memes are used to send a message that is funny and relatable, which is ironic because that seemed to mimic how students' defined a meme. For example, Steven and Scott from Silvercliff Academy discussed that memes help reflect true circumstances:

> Steven: Like sometimes, you realize like how this can relate to you in a certain way.
>
> Scott: If they're like more relatable, it means more entertainment, more funnier.

Willow from Westpine High School furthered Scott's sentiments, acclaiming, "Well it's funny because they agree with it that's why they relate to it and laugh." Other focus groups matched those same sentiments, as Mary and Melissa from Moorhall stated:

> Mary: Some of it has to be real or else it wouldn't be relatable to people and people won't like it.
>
> Melissa: I mean it doesn't have to be completely real but it has to make sense in a way.

Nevertheless, the participants collectively decided that a meme's purpose has some aspect of relatedness, but interestingly, the word "relatable" by definition implies an established connection or association; therefore, the sheer fact of participants saying it is relatable means there is a connection or established association with meaning or intended message of the meme. The word "influence" by definition is the capacity or power of a thing to affect actions, behaviors, opinions, etc. So when students are looking at memes as relatable, they are not only making a connection to an image, but they are also empathically connecting it to a previous event or experience. Interestingly, when Scott said the more relatable the funnier, it is because he was able to produce meaning and connect it to a social experience or experiences, and such moments assist in producing a social identity. The meme was connected well beyond the iconic or textual representation; it generated an interconnected web of meaning (Garzone & Catenaccio, 2009).

Several participants previously mentioned mathematics memes going viral, spreading just like a virus from person to person via the Internet. Viral memes are interesting and inspire viewers to share them, gaining more notoriety every time they are passed along. When a meme goes viral, not only is it a reflection of multiple people's experience depicting the intersectionality between their identities and the message being displayed, but also it creates and unites a common audience around a common idea, which by definition depicts an affinity group. Whether the meme transmits feelings of happiness, anger, or disgust, sharing it allows others to share those feelings, express virtual empathy, and validate social acceptance, leaving behind feelings of isolation. Sharon from Silvercliff Academy mentioned that though negative memes are dissatisfactory, they help attract people to a shared experience or view, which ironically is a sign of relief for not being the only one. She stated, "It's like sometimes when you think you're the only one who experiences that, but like it's actually not only you." Empathically comprehending another perspective, I probed further, asking participants if they would share negative memes with a younger sibling. That line of questioning removed participants from the focal point and emphasized their honest perceptions of influence. The questions led to a lot of notable comments.

Michelle from Moorhall shared similar sentiments to Sharon, stating that she would show negative mathematics memes to her sister because she is "bad" at mathematics and the memes would help her feel "normal." She added, "It will make her feel like better about herself because then she knows she's not the only one out there that's bad at math…." Moreover, Samuel from Silvercliff Academy added, "Yeah. 'Cause it's not like my little sister is dumb. She obviously understands and she also hates math. She's past the point where in kindergarten where you're counting, you know?" Interestingly, both Michelle and Samuel have implications that their younger siblings' identities are confirmed and concrete and therefore negative memes wouldn't be harmful. Michelle indicated that the negative imagery would be beneficial to respond to the feelings of seclusion and support the message that "it is OK to be bad at mathematics."

Similarly, Francesca from Fairbourne Prep stated:

> I'm the youngest so I guess I'm going to have to pretend but I feel like he or she would just look at this [memes] and be like LOL [laugh out loud], but I think that's the furthest it would go…. For example, how we are looking at number seven [meme 7] is a negative stereotyping for girls because we don't understand math, but I think someone who is younger would not really see it as that. They would kind of just see it as like the meme itself and that's it and not in depth. So I feel like it wouldn't really affect them as much as people who actually understand the context or subtext.

Correspondingly, Mike from Moorhall Mike stated, "Some minds aren't mature as others to understand it mentality." Notably both are cognizant of the harmful effects but contend by hypothetically assuming their sibling would not comprehend the gravity of the meme's message.

Comparatively, the majority of participants affirmed immediately that they would not expose their siblings to the negative mathematical messages because of their subliminal influence. For example, Antwon from Marblepond Charter admittedly stated, "If they see a whole lot of [negative] things about math, they might not see math as the best, or maybe not interesting or popular to be good at." In a like manner, Mary from Moorhall shared that she did not want her sibling to feel isolation among other people because others don't agree with them. She stated, "They might even be like oh I'm like the only person who could understand this stuff, maybe I'm weird."

Similarly, Willow and Wakanda from Westpine High school asserted respectively:

> Willow: No because I feel like in these memes there are more negative than positive or neutral. So its like I want them to see the better side of math, not people complaining about math.
>
> Wakanda: I wouldn't want my younger siblings to see that math is really complicated or confusing. I want them to excel, to do better and be strong, so that the positive things can come to them.

Scott from Silvercliff Academy conversely took a different approach from his focus group mate Samuel. Scott declared that he would not expose his sister to negative memes because “my sister like, just like Samuel’s sister, dislikes math but I want her to like math … for me I says that the subject is very important … you have to learn it [math], and without math you can’t do anything.”

Felicia and Fae from Fairbourne Prep affirmed that they want their younger sibling to encounter mathematics in an unbiased manner and define it through their honest experiences. Felicia similarly added that she wanted her younger sibling “to have an expectation of what math is going to be like. Even though it is going be challenging but they will figure it out eventually.” Fae correspondingly added, “I do have a little brother and when he come home and shows me all this stuff, he says math is going to be so hard. And I want him to be able to not think like that and want him to think he can be able to do it.”

To summarize, all the testimonies signify the power of memes as an influential agent to affect the perceptions and behavior of siblings. Some participants listed the benefits of negative memes, and others listed coping mechanisms for the negative messaging, but all are undoubtedly acknowledged the potential impact of memes.

Though many participants stated that memes were relatable and acknowledged their influential capabilities among their younger siblings, some students like Scott from Silvercliff Academy believe they are impervious to messages from memes. He said, “No, no, ‘cause they’re just, relatable and they don’t influence.” To further that, Melissa from Moorhall stated, “I don’t know I just read it and then I scroll, it doesn’t affect me.” Mike then asked her, “So there’s not one point in your life where you thought about it?” And she replied, “No, I don’t need to think about it, there’s more important things to think about.” Matt from the same focus group went as far as to call people “gullible” if they believe it or let memes influence them. Wilson from Westpine High school stated that people interpret memes in different ways but they have to realize the difference between "reality and fake." The irony here is that some of the same participants (Scott, for example) that articulated that the memes would be influential in shaping their sibling's identity now rejected the influence of memes on themselves.

Other students like Samantha, on the other hand, were opposed, stating that "they [memes] reflect on like real thing," so they had to be influential. Michelle, Mike, and Mary from Moorehall's focus group discussion stated that students are aware of what influences them.

> Michelle: I think everything has somewhat of impression on somebody, so it could be the smallest little thing.
>
> Mary: They may not even realize it … or think deeply about it.
>
> Mike: Some people might even say it and read it and won't even realize they're doing it.

The three were saying they believe memes are consciously unperceived but yet are also perceived unconsciously; when students interact with memes, there is an impact.

Samuel from Silvercliff Academy stated, "So when everyone is making fun of math, you're also going to want to make fun of math. When everyone's saying math is hard, even if you're good at it, you're probably going to say it's [math] hard." Samuel's comment initiated an interesting debate between Sean and Samantha.

> Sean: That's like someone telling you that you suck at something, like what if you're on the basketball team or something and they're telling you, you can't play, you can't do this, and you're just like, oh, all right, I can't play. That's the same.
>
> Samantha: Why you let someone have that much influence on you and why are you listening. If they say that you're bad, you don't have to think that you're a bad player. Like you can just push yourself forward and show them that they have nothing on you.

This was interesting because both students agreed with Samuel's earlier comment about community influence from a mathematics perspective. Though the context was different, the concept was the same, but Samantha conversely added a message of perseverance. Why? Basketball could be considered a skill, and so can mathematics. Seeing the parallelism between their conversations, I asked the participants if they saw any connections between Samantha's and our focus group's discussion. Students immediately looked puzzled, but eventually they said yes, though no one gave a further analysis. Did they not see Samantha's message of persistence applicable to mathematics? Transparency between the two examples might have been obscured because of minor details. In Sean's basketball example, the emphasis is on the person. The person is being told directly they are not good, which warrants immediate adjustments. Meme are making fun of mathematics as a whole. No one person is directly emphasized, so it's less personal and less urgent in this case.

When examining all transcripts, there was a suppressed undertone of the author's intended purpose. Sean stated, "…they [memes] can influence people 'cause like, you know, people make memes." People make memes, not machines, not computers, but people do. As stated earlier, creating memes is not an arbitrary action. The author consciously makes decisions based on their actions, experiences, thoughts, and feelings. To further that, Francesca from Fairbourne Prep acclaimed that meme are unintentionally influential. Intention usually implies some aspect of the author's purpose, which is usually unknown for memes, given that they can be created anonymously and distributed around the world in seconds. Francesca stated that memes are unintentionally influential, meaning most people are unaware of the author's intended purpose but interpret it and show some significant influence, whether big or small. People do not deliberately acknowledge that they are agreeing or disagreeing with the meme's message, but the impression can objectively be seen through their actions. Felicia added, "They [memes] can all have a different purpose in my opinion, I just don't think all are going to make you laugh, they can be like oh my god I can totally relate, or oh my god that's so funny or both but its not always the same thing." The messages behind memes are sophisticated and complex aspects to understand. Students examine memes and form their own interpretations of the authors' creations, which isn't trivial. But is it limited? When one-person looks at a meme, they are trying to form meanings based on the image selected by the author and the caption selected by the author. Weber and Mitchell (1996) stated, “While images always maintain some connection to people, places, things, or events, their generative potential in a sense gives them a life of their own, so that we not only create images, but are also shaped by them” (p. 305). Their interpretation isn’t arbitrary; it is limited to some extent of the author’s intended purpose.

Additionally, Fairbourne Prep’s Falyn described memes as a “reaction” to people’s conceptions about mathematics. She stated, “They [memes] are also based off of stereotypes.” Moreover, by definition, “stereotypes” means unfair or untrue ideas or views widely held by many; therefore, these stereotypical ideas could be inserted into mathematics memes, especially if the idea is commonly understood by many. For example, a selected racial group easily understands “math,” or that mathematics is only accessible to “nerds,” or even that mathematics success is gender-dependent. These are ideas that persist today in meme form and create a divide, as referenced by Francesca from Fairbourne Prep, who stated:

> Anything that has to do with math in a negative way is influential because it’s saying that regular people don’t like or understand math so it’s kind of not really expected but it’s OK if you don’t. Like if you do then you are different from the rest, and that can be seen in either a positive or negative way. Because if you are for example like when you understand something which is number two [meme #2] it could be a good thing for yourself and other people can either see you as smarter or as a nerd.

Lastly negative mathematical memes present different levels of contrast with students’ backgrounds but reinforce negative mathematical messages and influence mathematical behaviors. Students are not naïve or blind to negativity; the common messages help evoke and manipulate emotions to respond appropriately. Francesca closed with: “I think it’s like the expectation, like math is hard so I do not really expect myself to do well or I don’t know like excel because it’s like always hard. So you know I’m lucky if I understand it. So it’s kind of legitimizing that thinking.”

Although containing a limited sample size, these analyses show that the messages generated from memes can be very powerful and can influence one's mathematics identity. All participants felt mathematics memes to contain relatable features of their own personal mathematics experiences illustrating, an interconnected nature between the meme's message and an individual's identity. Having participants characterize and express their disposition of exposing their younger siblings to this inventory revealed important components from a unique context. Participants illustrated concise insight of how negative mathematical memes would impact not only their siblings' perceptions but their ability as well. Eccentrically this method provided an important interpretation of negative mathematical memes and their role. Regardless participants' responses led to the proliferation of influence of mathematical memes. Declaration became more obscure when participants made personal conjectures. The differences of perception were determined by minor characteristics in student agency; did participants define their moments of struggle as just moments or something greater? Nevertheless, their responses confirmed that memes are a new, highly sophisticated form of media that can help forge identities, and as their ability to virtually reach an unlimited audience amplifies, it will continue to impact identity construction.

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The results of the study will be summarized in this chapter, followed by limitations, implications of findings, and recommendations for further research. This study was conducted with 31 secondary school students. Through the course of focus groups and an individual Internet meme activity (IMA), I examined the messages societal influences (i.e., memes in popular culture) were disseminating regarding mathematics to participants. Additionally, I also analyzed whether participants were internalizing the messages received and whether or not the messages were influential to mathematical identities.

Review of Research Questions

Research Question 1

The initial research question focused on what messages students were receiving about mathematics from memes in popular culture. The first question comprised several components regarding what messages students were receiving. Specifically the intent was to first analyze messages of memes prior to viewing the meme inventory. After examining their responses, interesting patterns emerged. A majority of students actually described memes exemplifying mathematical problem such as a system of equation meme problem or an order of operation meme problem. Nevertheless, this demonstrates students creating and exploring online and social media platforms as a new mathematical space (Walker, 2012). Though the preponderance was neutral, there was an assortment of negative mathematical messages in their descriptions. Messages such as “math is difficult”; “math is confusing”; “math is abuse”; and “failing is inevitable, no matter the effort” were all-common in their portrayals.

Students were then task with defining the 9 mathematically referenced memes from the inventory as positive neutral or negative. After analyzing results, there were discrepancies with how participants coded specific memes and adults coded specific memes. This finding suggests differences on how adults and student distinguish or experience memes.

Furthermore, there were six core themes identified from the meme inventory: (1) stereotypical views of mathematics; (2) mathematics is too complicated; (3) effort in mathematics; (4) mathematics is useless; (5) mathematics is not fun; and (6) sense of accomplishment. Though the themes seem distinct, some intertwine with others. If math is perceived to be difficult prior to an experience, how much effort will one put forth? If the proper effort is not implemented in a seemingly difficult subject, the objective is questioned. With all of this, why would math be fun? Overall, participants’ experiences characterized a belief system that illustrates the benightedness of mathematics and its importance (Martin, 2000).

Mathematics being characterized in such a manner is not a new discovery but rather an old one but its prevalence is a unique discovery. Olden day messages have transcended into meme form.

Research Question 2

In review of the second research question, the focus was on how students were internalizing messages about mathematics. Specifically, two data sources were addressed to answers this question: (1) descriptions of their hypothetical mathematical meme; and (2) their social media practices (i.e. liking, commenting, sharing, and creating).

Giving participants' free rein to describe any mathematical meme they would create was a venerable method to provide insight into which mathematical messages were being internalized. Unfortunately, my findings demonstrate not only are memes being used to depict mathematical stereotypes but also an abundance of hypothetical memes reinforcing negative mathematical messages. Findings also demonstrate students' exhibit an overwhelming amount of negative social media practices (liking, commenting, sharing, and creating) that support this prerogative with little to no resistance from opposing perspectives. Though each participant had varied experiences with mathematics and 80% of participants self-identified as above average mathematics ability, the majority of participants created negative memes, and all agreed to negative online practices. The saturation of negative mathematics memes and online practices was a prevalent finding and indicates not only the assimilation of a culture where being bad at mathematics is socially acceptable, but inter-culturally borrowing to create a new aspect to the given culture, which is problematic because the Internet is an open medium that young people can access easily (Teppo, 1998).

Research Question 3

The third research question focused on examining whether or not messages from memes are influential to mathematics identities. Specifically, the data was elicited from field notes and participants describing whether or not they would feel comfortable displaying memes to their young sibling.

Throughout the research, participants branded mathematical memes as relatable, which is telling because they are indicating there is an established connection or association with the meme's message. Beyond the meme's iconic or textual representation, the message generates an interconnected web of meaning. Ironically, having participants shift the focal point to their younger siblings revealed their authentic perceptions of a meme's influential capabilities. Unexpectedly, participants' consideration were mixed. Some participants affirmed that they would not want their younger sibling(s) to view negative mathematics memes because of their subliminal influence. Participants said they preferred their siblings to encounter mathematics without bias and define it through their honest experiences, not through memes. Adversely some participants agreed that they would show negative mathematics memes to their younger siblings. Their decisions mainly stemmed from the fear of alienation their siblings might face. Participants were attempting to utilize negative mathematical memes' influential capability as a hopeful prospect. Nevertheless, all expressed concern that the messages siblings receive from memes in popular culture are influential. However, participants were more resistant to acknowledging a meme's potentiality when the emphasis was shifted back to them. The irony here is that some of the same participants that supported the claim that memes are influential in shaping minds around mathematics now contradicted themselves. Some students, however, had different stories, made up of varied circumstances, and a varying degree of influence from memes.

Overall, the portrayal of not only mathematics but also the people who excel at it in popular culture, specifically memes, affects students' mathematical identities and may prevent young students from finding interest in the field and/or affect their participation in mathematics (Wood, 2013). As stated by Nasir (2002) the fluidity of mathematics identity—that one's mathematics identity depends on contextual experience—was witnessed throughout this study. And it is important to note that the process is not a socially or culturally neutral process (Jackson, 2009). Latterell and Wilson (2004) summed it up by stating, "Students shut mathematical doors early in life and it is difficult to open a mathematical door later in life" (p. 12).

Limitations

When considering the findings and the implications of this study for practice and future research, there are important considerations to bear in mind about this study. It did not attempt to use popular culture as a mechanism to advance curriculum in mathematics nor as an attempt to alter teaching methods. I merely set out to explain in the words of 31 students and how they reported the impact of popular culture. This study's main focus was to capture the messages about mathematics that students were receiving from popular culture, specifically memes, examine whether or not students were internalizing the messages, and analyze the effects on mathematical identities.

Though a jury of mathematics professionals was formed to select the memes used in this study, there were degrees of subjectivity used throughout. The meme inventory was primarily dependent on Google searches on the Internet and social media searches. As a result of a plethora of stereotypical imagery (i.e. people with glasses, older White, and Asian males, etc.) the final meme inventory heavily favored male figures. A second limitation of this study was that the sample was drawn from a pool of my professional network. Lastly, another drawback was having teachers select the final student participants based on their discretion because it may not have been representative of the entire group of willing participants (i.e., 94% of the study participants were underclassmen and 80% of participants identified as above average math students).

Though it was not my intention, an indirect benefit from the study was having students thoughtfully analyze and reflect on their own experiences, hopefully gaining personal insight about what messages of mathematics are produced in popular culture. By virtue of those insights, the students may have gained a new awareness about non-authentic messages and built a resistance toward them. Students could have learned the impact of popular culture and how messages can subconsciously impact students' lives.

Implications of This Study

This research serves as a catalyst that signifies the conceptualizations of power, knowledge, and identity that are rooted in social media. This study offers a deeper understanding of the influence of popular media and its association with mathematics identity and mathematics performance. This section highlights a few ideas about the implications for mathematics teachers and teaching, and mathematics curriculum, but it is not solely based in research. My insights as the researcher and as a mathematics teacher are also discussed.

Implications for Teachers

Mathematics teachers play a critical role because they are the primary agents of mathematics socialization within the school context and are monumental in perpetuating the ideologies of mathematics (Martin, 2000). Popular culture permeates the facets of our lives and is not easily avoidable; therefore, I suggest that teachers utilize memes and popular culture as a tool, rather than accept them as a hindrance to individual authority. To begin to understand how our students can develop the capacity to deal with the implications of popular culture, Appelbaum (1995) recommends that teachers "become more cognizant of ongoing popular culture curriculum and comprehend the relevance of public and professional discourse of mathematics education as an ongoing practice in and out of school" (p. 46). Furthermore, teachers should consider the potential effects on their students. Joseph Schwab (1970) mentioned that education needs to be more cyclical, wherein the four dimensions (the teacher, the curriculum, the student, and the social milieu) reinforce and influence one another.

Moreover the results of this study also show that students are unaware of the processes and proficiencies of mathematical learning. More specifically, helping students understand knowledge is not transmitted by copying notes or that teaching strategies need to account for students being apprehensive to ask questions in a mathematics classroom.

Lastly, teachers need to make more of an effort to illustrate how mathematics is emerging in their students' lives.

Examining the results of this study further, students grow up being exposed to many different messages about mathematics, with no formal space to debrief their thoughts and sentiments. The oversaturation of negative messages about mathematics becomes a prevalent message, one that is seemingly valid because it is illustrated and portrayed in so many different ways. Its rationale only grows when those depictions are not challenged. By teachers not consulting or discussing with students the messages found in memes, whether positive or negative, they potentially legitimize popular culture's presentation of mathematics mainly in a negative light, enabling the production of meaning and potentialities lost.

The challenge for teachers is going to be how they can offer sufficient time for conversations to happen because it would be beneficial to provide students with opportunities to explore and critically reflect on popular culture's representations of mathematic. Perhaps such conversations can set the threshold, and normalize the need for what should take place in mathematics classrooms. Using popular culture (television, movies, memes, etc.) in the classroom can provide a forum to empower students to become more media-literate and encourage them to think about how the media situates them and shapes their mathematics identities.

It is important to remember in subsequent discussions not to put emphasis on the prescribed roles of teacher and student but to attempt to link experiences to learning, coming together to draw information from several sources, synthesize and evaluate the data so that, in the end, students are able to apply meaning in to contexts beyond the original situations.

Implications for Curriculum

Taking the findings of this study into account, how we commonly characterize mathematics learners needs to change, as we disregard the multiple spaces in which students learn and do mathematics lacks attention to students' multiple identities. Mathematics is so evident in our social realm today that Appelbaum (1995) suggests, "that mathematics educators can extract potential curriculum materials from virtually anywhere. Teachers can bring it into their classrooms and utilize it as a tool to enrich, motivate, provides social context, and heighten the significance of mathematics" (p. 44). The National Council of Teachers of Mathematics (NCTM) has begun to recognize the importance of more relevant curriculum that speaks to the mathematics learners of today as they have created online resources and supplemental tools in an attempt to link mathematics curriculum to popular the television show NUMB3RS. One thing is clear; mathematics has transcended the classrooms in specific ways (i.e. figure 5.1.) Teachers can venture down the avenue of using such examples in their classrooms in a variety of way. For example a teacher could use Figure 5.1. as an error analysis tool. Specifically, "Derek left a comment on this meme stating the answer is 60. Jennifer left a comment stating the answer is 25. Jacqueline stated they both were wrong but could not figure out were they made their mistake." Such questions get students to explain their reasoning, critique other answers as well as tease out common misconceptions.

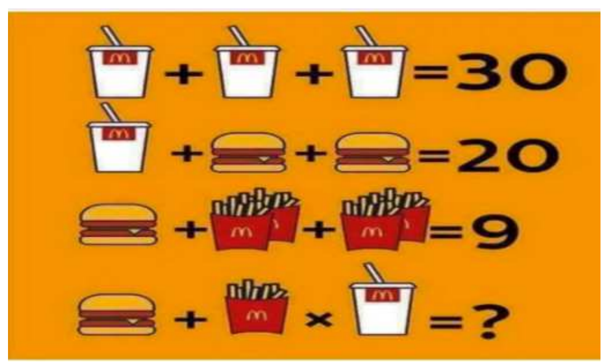


Figure 5.1. System of Equations Meme

Alvermann et al. (1999) assert that it is important for curriculum to find a cohesive blend of enjoyment, engagement with content, and critical analysis of media. Additionally, the projects ask students to interact with mathematics existing in society, which promotes students' discovery and reflection on the relationship between mathematics done in the classroom and mathematics portrayed in the media.

Also absent is the discourse in mathematics education are the relationships between mathematics and real opportunities (Martin, Franco, & Mayfield-Ingram, 2003). Previous researchers such as Skovsmose (1994) have noted that some mathematical curriculums lack the authenticity of "real" application. Skovsmose states:

> Applications of mathematics are difficult to observe and therefore to express an opinion on.... When the children fail to realize that mathematics is in action, they don't have any chance to question their opinions about it. When they do not realize that they are using mathematics, their image of the subject as belonging only to a textbook is not challenged. (p. 96)

By no means do these suggestions indicate a seamless transition, but instead will require workshops and professional development for teachers and administration. Teachers need time and opportunities to make sense of media influences, students' perceptions, their teaching style, and strategies.

Recommendations for Further Research

The data and findings of this study have multiple implications for future research. As a result of the focus group discussions, the participants articulated using social media platforms to discuss, complete, and circulate mathematical memes that contained a mathematical problem. I suggest an investigation into the "new" online mathematical space students are utilizing; it will be interesting to gain insight on what makes these specific memes go viral. What are the common misconceptions highlighted through the other answer choices? What are the corresponding comments being posted along the individuals' answers? Are individuals learning from their mistakes and other answer responses? How are we facilitating effective mathematical spaces for young people? Another path for further research would be to have participants actually create mathematical memes and post them on their social media platforms. It would be interesting to understand how participants construct their memes? What picture they selected because pictures have their own embedded message. What caption they would write? What would be their intentional message? And how the audience takes their message? Needless to say, I think there are some interesting implications for further research embedded here.

Furthermore, due to the mixed findings on whether or not participants would display negative mathematics memes to their younger siblings, another research suggestion could be geared toward gaining further insight on when students are most susceptible to the effects of negative mathematical messaging. Are there processes that teachers can implement to reconstruct students' mathematical identities? Would it help to create and expose students to a database of positive mathematical memes? Would the creation, implementation, and facilitation of any of the strategies and/or activities suggested above in the implications section strengthen students' mathematical identities? Is there a relationship between mathematics ability and how students perceive mathematical memes? Are stronger mathematical students less susceptible to negative mathematical messages?

I suggest a replication of this study but there are multiple avenues for change. If possible, the study should consider a more evenly distributed group in terms of grade, gender, and mathematics ability. Additionally, the data from this new study may also be used to look more closely at, compare, and contrast the differences among participants' mathematics identities from an individual perspective and a social or group perspective. Moreover the new study could also examine the conceptual distinctions between how participants view themselves and how others see them.

Lastly, I recommend the replication of this study but using a different analysis approach. Using discourse analysis to analyze these data would be extremely helpful to distinguish any differences between what participants said and what participants meant

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Appendix A

Promotional YouTube Video

- https://www.youtube.com/watch?v=EENZQFZolAM&t=34s

Appendix B

Promotional Flyer

Appendix C

Student Assent Forms

Teachers College, Columbia University
525 West 120th Street
New York NY 10027
212 678 3000

Assent Form for Minors

Protocol Title: An Investigation of Mathematics in Popular Culture; An Analysis of Mathematical Internet Memes

Principal Investigator: Gregory Benoit, EdD candidate Teachers College 617 – 671 – 6823

Read: We are looking for high school students to participate in our study. The study is about on mathematics in popular culture. The study is broken down into two parts. In Part I we will ask some questions about background questions and questions about mathematics, like: how you feel about it, experiences you've had in mathematics, if you've seen mathematics in popular culture, etc. In Part II you will be ask to play in a matching meme activity. 15 Math memes will be placed on the table and you will be asked to place them in groups according to commonalities or relationships you've determined. Then you will explain the groups you've created and why. This interview will be audio-recorded and I will be taking notes along the way.

I agree to be audio recorded   Yes ☐   No ☐

I______________________________ (child's name) agree to be in this study, titled *An Investigation of Mathematics in Popular Culture; An Analysis of Mathematical Internet Memes.* What I am being asked to do has been explained to me by _Gregory Benoit__. I understand what I am being asked to do and I know that if I have any questions, I can ask _____GregoryBenoit___ at any time. I know that I can quit this study whenever I want to and it is perfectly OK to do so. It won't be a problem for anyone if I decide to quit.

I am 17 or younger and I <u>assent</u> to participate in the study.
Signature: __________________________

Date: __________________________

Witness: __________________________

If your are 18:

I am 18 and I <u>consent</u> to participate in the study __________________________

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Investigator's Verification of Explanation

(DO NOT FILL OUT OFFICEUSE ONLY)

I certify that I have carefully explained the purpose and nature of this research to _______________________________ in age-appropriate language. He/she has the opportunity to discuss it with me and knows that they can stop participating at any time. I have answered all of their questions and this minor child has provided the affirmative agreement (assent) to participate in this research study.

Investigator's Signature ____________________________________

Date _______________

IRB protocol: **16-312**

Appendix D

Parental Permission Forms

Teachers College, Columbia University
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New York NY 10027
212 678 3000

PARENTAL PERMISSION FORM

Protocol Title: An Investigation of Mathematics in Popular Culture; An Analysis of Mathematical Internet Memes

Subtitle if needed: Interview Consent Form

Principal Investigator: Gregory Benoit, EdD candidate Teachers College 617 – 671 – 6823

INTRODUCTION

Your child is being invited to participate in a research study called "An Investigation of Mathematics in Popular Culture; An Analysis of Mathematical Internet Memes." Your child may qualify to take part in this research study because they are between the ages of thirteen through nineteen and are in a math class. Approximately twenty-five children will participate in this study and it will take no longer than 2 hours of your child's time to complete.

WHY IS THIS STUDY BEING DONE?

Your child is invited to participate in a research study on mathematics in popular culture (TV, Movies, Internet). We believe interviewing students will help us make connections between their beliefs about their mathematical abilities and images found in popular culture.

WHAT WILL MY CHILD BE ASKED TO DO IF I AGREE THAT MY CHILD CAN TAKE PART IN THIS STUDY? (Describe the research procedures in chronological order step by step.)

The research will be conducted in person after school at your child's school by researchers.

If you decide to allow your child to take part in this study, your child will asked to do two things. First, the principal investigators Gregory Benoit and Gábor Salopek will interview your child. During the interview they will be asked to discuss their experience with math and their experience with mathematics in popular culture. Second they will participate in a meme matching activity. 9 pictures having to do with mathematical will be placed in front of them and they will be asked to place them in groups according to relationships they determine. Then they will explain the groups they created and why. This interview will be audio-recorded and the principal investigators will be taking notes. After the recorded interview is transcribed the original recording will be deleted. If you do not wish your child to be audio-recorded, your child will not be able to participate. The interviews will be individual and take approximately ninety

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minutes. Your child will be given a pseudonym or false name in order to keep their identity confidential.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN MY CHILD EXPECT FROM TAKING PART IN THIS STUDY?

This is a minimal risk study, which means the harms or discomforts that your child may experience are not greater than your child would ordinarily encounter in daily life while having a routine conversation. Your child might feel embarrassed to discuss problems in math o their belief about the subject. However, your child does not have to answer any questions or divulge anything they don't want to talk about. Your child can stop participating in the study at any time without penalty. You might feel concerned that things your child might say might get back to their teacher. The principal investigator is taking precautions to keep your child's information confidential and prevent anyone from discovering what they say or their identity, such as using a pseudonym **and codes** instead of their name and keeping all information on a password protected computer and locked in a file drawer.

WHAT POSSIBLE BENEFITS CAN MY CHILD EXPECT FROM TAKING PART IN THIS STUDY?

There is no direct benefit to your child for participating in this study. However, the principal investigator is a math teacher and researcher and will be honored if your child were to participate. Your child will also receive a pizza party upon completion of their interview.

WILL MY CHILD BE PAID FOR BEING IN THIS STUDY?

Your child will not be paid to participate but they will receive a small token of appreciation(i.e. a pizza party) . There are no costs to you for your child's taking part in this study.

WHEN IS THE STUDY OVER? CAN MY CHILD LEAVE THE STUDY BEFORE IT ENDS?

The study is over when your child has completed the interview and matching activity. However, your child can leave the study at any time even if they haven't finished. They will still receive a pizza party.

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PROTECTION OF YOUR CHILD'S CONFIDENTIALITY

The investigator will keep all written materials locked in a desk drawer in a locked office. Any electronic or digital information (including audio recordings) will be stored on a computer that is password protected. What is on the audio-recording will be written down and the audio-recording will then be destroyed. There will be no record matching your child's real name with their pseudonym. Research data concerning children will be kept for five years.

HOW WILL THE RESULTS BE USED?

The results of this study will be published in journals and presented at academic conferences. Your child's name or any identifying information about your child will not be published. This study is being conducted as part of the dissertation of the Gregory Benoit, the principal investigator.

CONSENT FOR AUDIO RECORDING

Audio recording is part of this research study. You can choose whether to give permission for your child to be recorded. If you decide that you don't wish your child be recorded, they will not be able to participate in this research study.

______I give my consent for my child to be recorded ________________________________
Signature

______**I do not** consent for my child to be recorded ________________________________
Signature

WHO MAY VIEW MY CHILD'S PARTICIPATION IN THIS STUDY

____I consent to allow my child's written, and audio taped materials viewed at an educational setting or at a conference outside of Teachers College ______________________________
Signature

_____**I do not** consent to allow my child's written, video and/or audio taped materials viewed outside of Teachers College Columbia University ______________________________
Signature

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PARENTAL PERMISSION FORM

OPTIONAL CONSENT FOR FUTURE CONTACT

The investigator may wish to contact you in the future if there be any clarification that need to be made. Please initial the appropriate statements to indicate whether or not you give permission for future contact.

I give permission to be contacted in the future for research purposes:

Yes ________________________ No________________________
Initial Initial

I give permission to be contacted in the future for information relating to this study:

Yes ________________________ No________________________
Initial Initial

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?

If you have any questions about the study or your child's taking part in this research study, you should contact the principal investigator, Gregory Benoit, EdD candidate Teachers College 617 – 671 – 6823 or at gb2463@tc.columbia.edu

If you have questions or concerns about your child's rights as a research subject, you should contact the **Institutional Review Board** (IRB) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 10027, box 151. The IRB is the committee that oversees human research protection at Teachers College, Columbia University.

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PARTICIPANT'S RIGHTS

- I have read and discussed the informed consent with the investigator. I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my child's participation is voluntary. I may refuse to allow my child to participate or withdraw participation at any time without penalty to future student status or grades or services that my child would otherwise receive. I understand that my child may refuse to participate without penalty.
- The investigator may withdraw my child from the research his professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to allow my child to continue participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies my child will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.

My signature means that I agree to allow my child participate in this study

Child's name: ____

Print Parent or guardian's name: ________________________________

Parent or guardian's signature: _________________________________

Date: ________________

Appendix E

Principal Permission Form

Institutional Review Board
52 Chambers Street, Room 310
New York, NY 10007

APPROVAL TO CONDUCT RESEARCH IN SCHOOLS

To the Principal:

The research study described in the Proposal Submission Form has been approved by the Institutional Review Board (IRB) of the New York City Department of Education. (See the signed Approval Letter) This researcher is now seeking principals willing to cooperate in the study. Please sign below if you agree to have your school participate in this study.

In order to begin the study, the researcher must return this form to IRB@schools.nyc.gov – signed by the principal of each school that will be participating in the study to the IRB, Research and Policy Support Group (RPSG) before data collection begins.

NOTE:

Researchers who need to be in schools must have fingerprints on file at the Department of Education prior to field work.
Where data collection includes information from DOE administrative records, a data request must be submitted to RPSGresearch@schools.nyc.gov. Researchers may not request school or individual student records from school personnel.

Researcher/Principal Investigator:________________Gregory Benoit & Gabor Salopek________________________________

Title of Study:___ MATHEMATICS IN POPULAR CULTURE: AN ANALYSIS OF MATHEMATICAL INTERNET MEMES________

Research Will Involve:

Cooperating School	School ATS Code (DBN district-boro-school number)	Grade (s)	Number of Classes	Number of Staff/Pupils	Start Date of Data Collection

______________________ Principal's Signature

______________________ Date

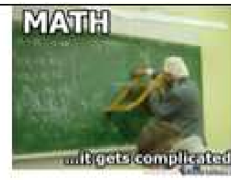
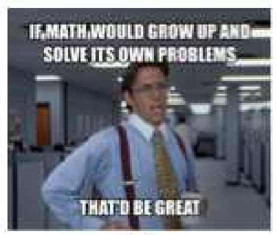
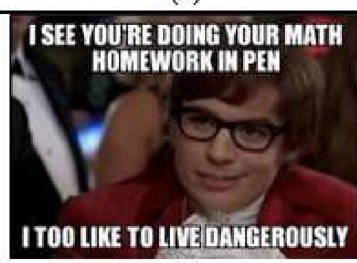
______________________ School

PLEASE DUPLICATE AS NECESSARY

Rev. 2/12

Appendix F

Final Meme Inventory

Postive	Neutral	Negative
 (7)	 (6)	 (8)
 (2)	 (9)	 (3)
 (5)	 (1)	 (4)

Appendix G

Student Activity Sheet

Name: Grade Level: Age: Gender: M F

Ethnicity:
Caucasian / Hispanic / African- American / Asian
Other:______________________

On Scale 1– 10 (10 being the best) rate yourself as a Math students
1 2 3 4 5 6 7 8 9 10

POSITIVE:	Numbers:	Discuss:
	WHY:	
NEUTRAL:	Numbers:	Discuss:
	WHY:	
NEGATIVE:	Numbers:	Discuss:
	WHY:	

Appendix H

Focus Group Discussion Questions

Script for students:

My name is Greg. This is Gábor. We are researching math in popular culture. The interview will be in two parts. We will ask you a couple of questions about math in popular culture as a group then show you some memes and have you place them in groups. Your answers will help us find a link between math education and popular culture. The interview should take anywhere from 45 minutes to one hour. Participation is voluntary and refusal to participate will not result in any consequences or any loss of benefits that you are otherwise entitled to receive. Should you need to stop the interview at any point, we can reschedule it for another time. Everything you say will be confidential, this is a safe space, so I encourage you to tell the truth. Are you ok with what we just talked about and can we continue? What is the best method to follow-up with you should anything need clarification?

GROUP (1st Part)

1) While on the Internet do you go on any social media website? Which ones, how many times?
2) What images do you see now? Do any of them pertain to Math?
3) What are people doing when Math is being portrayed?
4) How do the people look? (jeans/ cloths/ braids etc.)

   Show them a non- related meme → Funny Meme has nothing to do with math
5) What do you see in it? Describe it? Do you see this as a positive or negative or neutral?
6) Have you seen this one before?
7) In your own words what's a meme? What do you think their general purpose is? Do you think all memes have the same purpose? Do you think there are messages in them?
8) Do you think memes are an influential in anyways?
9) If you had to pass a message would you use a meme? Do you think they are influential ways to pass messages?
10) Have you seen any memes relating to Math? (If yes describe it) Explain

Individual (Session)

Show them Math memes on the table

{READ} Direction: In front of you are 10 different mathematical memes. Your job is to place each meme into one of the 3 categories (P/Neu./Neg). Place the number located on the back of the meme in the appropriate category on your student answer sheet. There is no right or wrong answer. There may not be an even number of each category present, matter of fact one or two categories may not be used.

It is up to you to place meme where you feel like they go. You are incomplete control!

So when you are done, write a description of why all those memes are in that category made (i.e. why are the ones you've selected Positive?

If you come across an interesting one and you want to discuss it further, place the number in the discussion category and we will discuss the most frequently chosen meme as a group.

If you come across one that you **absolutely** agree with or **absolutely** disagree with write the number in "Agree with" Box or the "Disagree with" box. And use the tape recorder and explain why you disagree or agree with it?

GROUP (2^{nd} Part)

11) Have you seen any of these Memes before? Or Meme like these? Please describe it?
12) Have you shared or posted any memes like this? If so, where? Why do you think you did that? What were the comments like?

Student May choose a Number to Discuss

13) Do you feel like there are messages behind any of them? What's the message behind it? How do you know?
14) If you had a younger sibling, would you let them read or see these memes? Why do you think?
15) Was it the picture that decided the message or the words (caption)
16) Do you think these memes are an influential in any way?
17) Do you think everyone interprets the meme in the same way? Do you think the message changes depending on gender or race or age?
18) If students consistently see these memes, do you think it will influence the way they think about mathematics? How

Appendix I

Pilot I: 25 Likert-Scale Questions and Four Constructed Responses

For this survey, **popular culture** is defined as the entirety of ideas, perspectives, attitudes, memes and images depicting diversity, trends, and styles. Popular culture is often expressed through multiple types of media, which includes television, movies, internet, social media, advertisements and commercials, and music.

Directions: The following pages contain a number of statements with which some people agree and others disagree. **Please circle the option that reflects how you personally feel or think.**

Circle your gender: Male Female

1. I am exposed to popular culture on a daily basis.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2. Popular Culture does not show Math in a favorable way.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3. If media showed celebrities being good at Math, people would do better at Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4. Media shows only nerds being good at Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5. I can find examples of Math in Popular Culture.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6. I can complete my math computations more accurately when I use technology.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7. It's cool to be smart in Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
8. I find that reading texts online is a helpful way for me to learn Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
9. I think popular culture has influenced me.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
10. Popular Culture often reflects mathematical topics.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
11. When I need help in math, I go online.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
12. When I see math in media, math is shown as being important.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13. Media often suggests that it is ok to be bad at Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
14. Media supports the idea of there being a "Math gene" – born being good at math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
15. Popular Culture is important to me.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
16. Popular Culture adds pressure to learning Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
17. Media illustrate math in a positive light.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

18. I find it helpful when Math is presented in media.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
19. I find that watching a video online is a helpful way for me to learn Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
20. Math and Popular Culture don't mix.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
21. Popular Culture often shows the cool kids as mathematically capable.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
22. I feel more comfortable doing math with technology.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
23. Popular Culture encourages me to be good in Math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
24. I have recently seen mathematicians shown in media.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
25. I think popular culture values other subjects more than math.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Can you provide an example or examples of Math being shown in popular culture? If so, list them.

What message does Popular Culture give you about mathematics?

What would make you value math more? What changes in media would make you value math more?

Are there items on this questionnaire that were unclear to you? If so please list them and tell us how we can change them to make the item(s) clearer.

Appendix J

Original Meme Inventory

Social Meme Jury Selection

Positive (P)   Negative (N)   Neutral (O)   Undecided (U)

You may also give suggestions and/or highlight ones you extremely like

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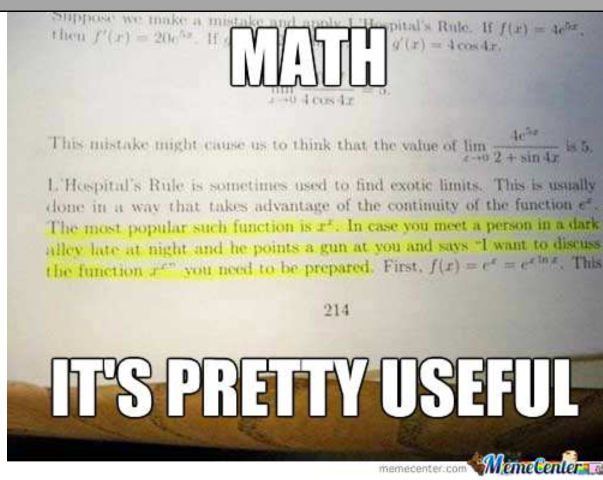
<tr><td>1</td><td>
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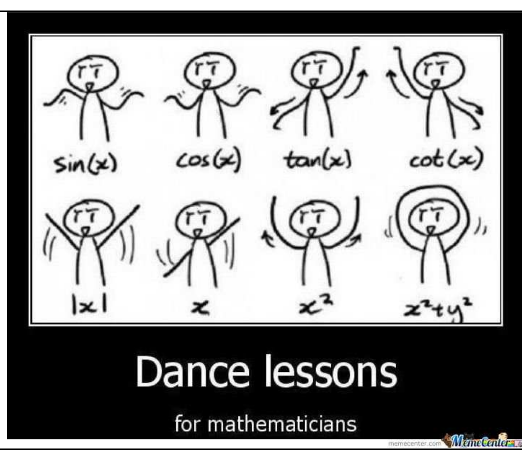
<tr><td>2</td><td>
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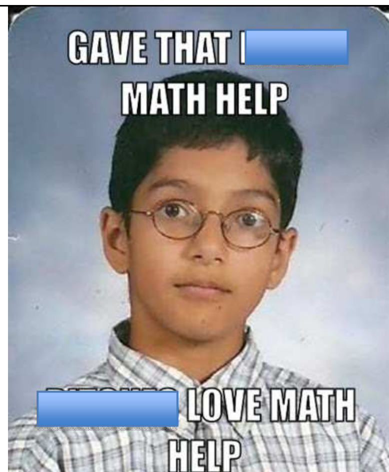
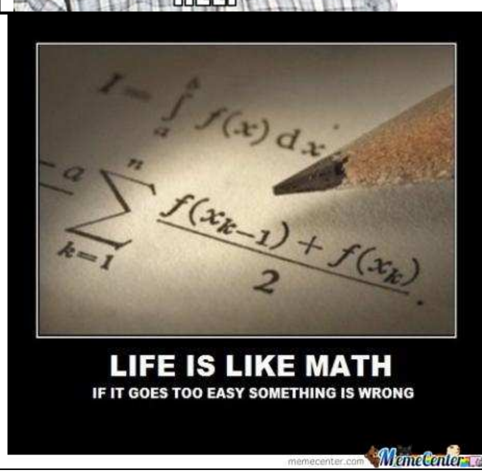
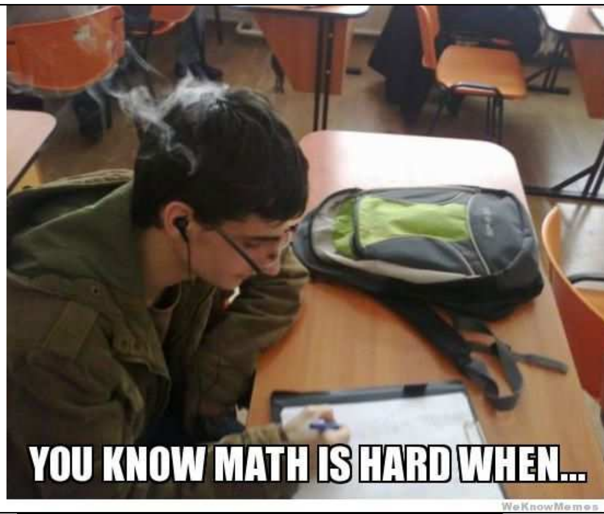
4		Suggestion:
5		Suggestion:

6		Suggestion:
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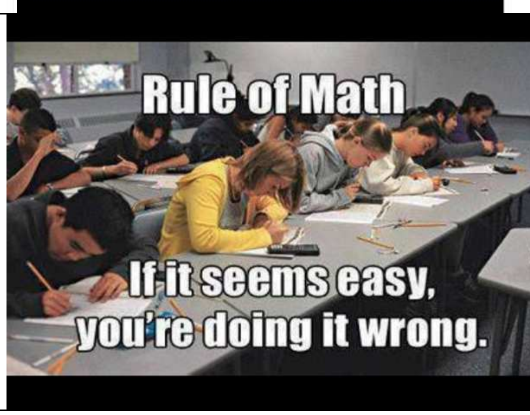
8		Suggestion:

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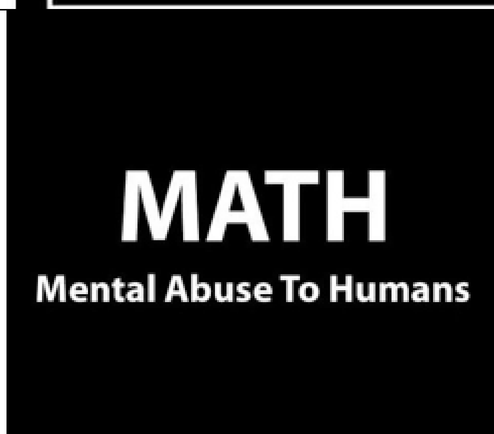
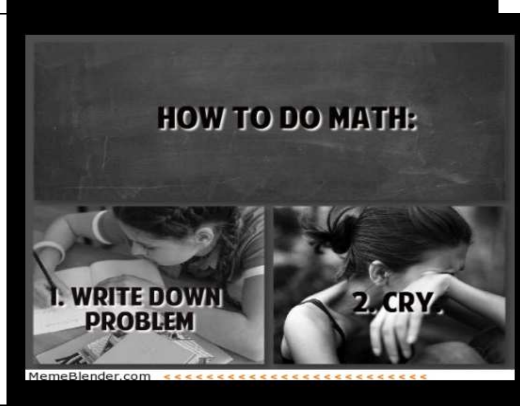
10		Suggestion:
1 **1**		Suggestion:

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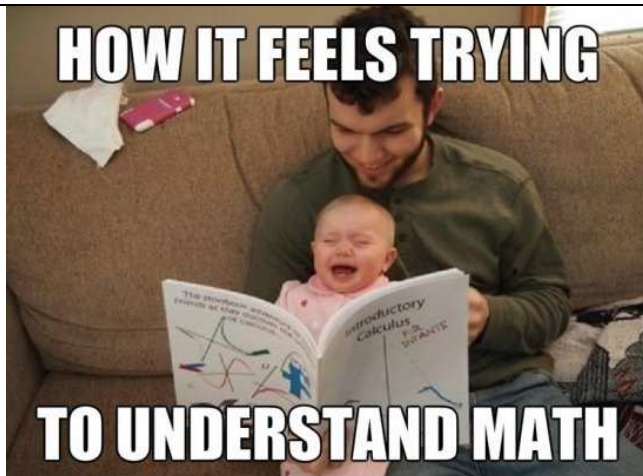
<tr><td>12</td><td>
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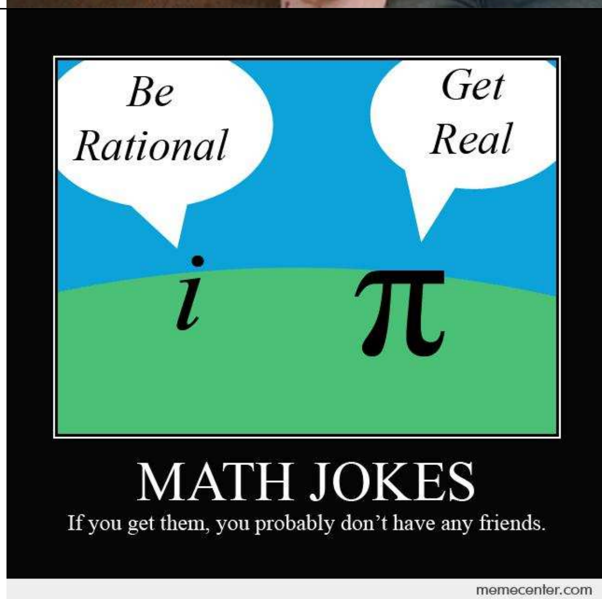
<tr><td>13</td><td>
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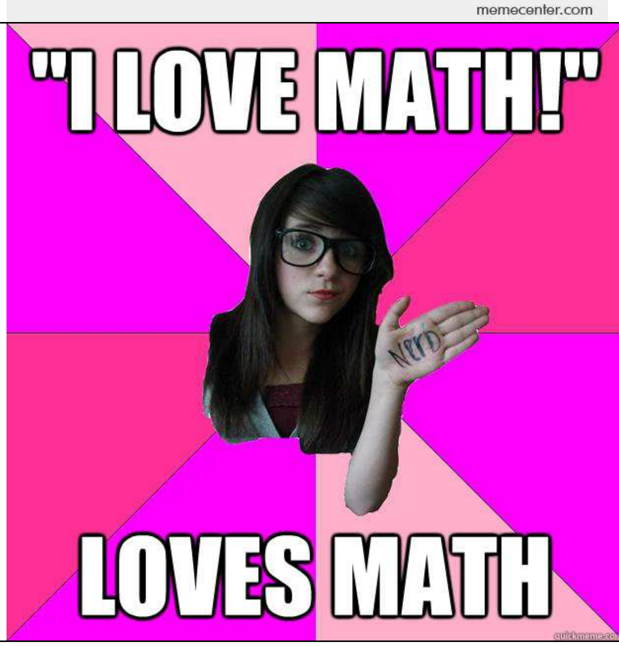
<tr><td>14</td><td>
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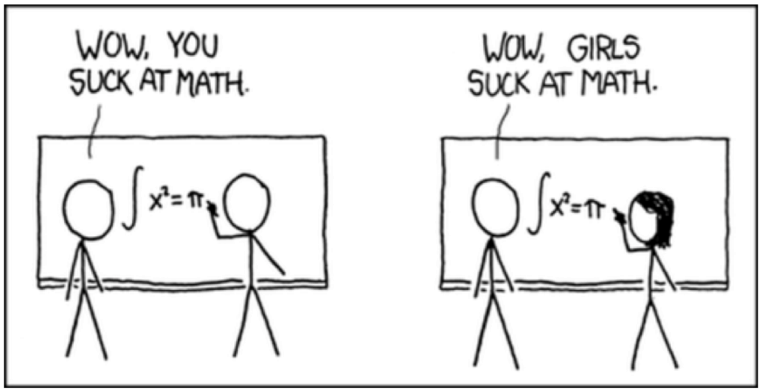
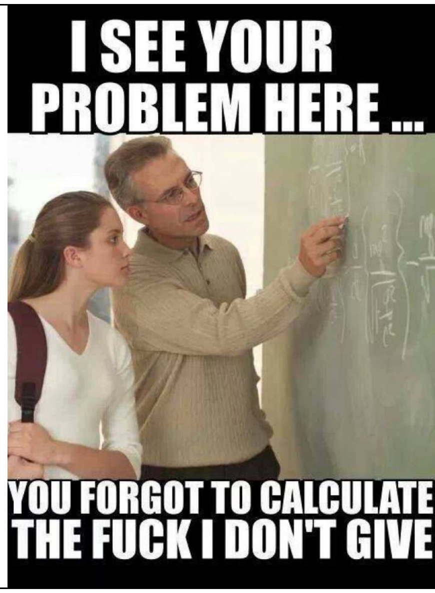
15		Suggestion:
16		Suggestion:

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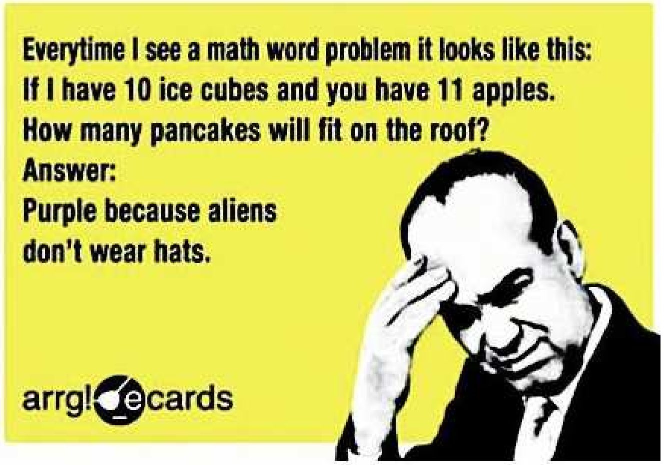

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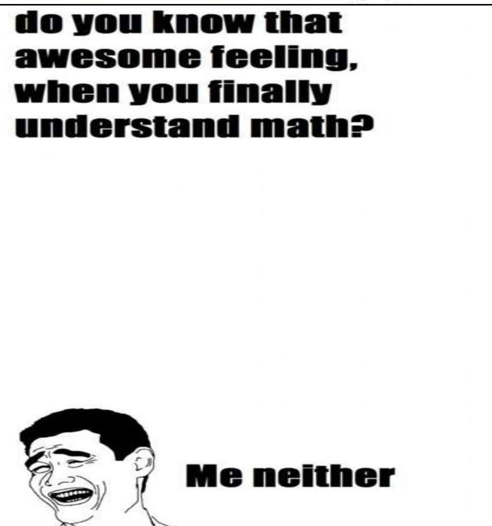

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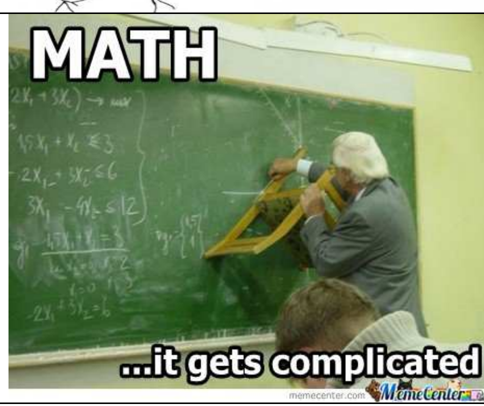

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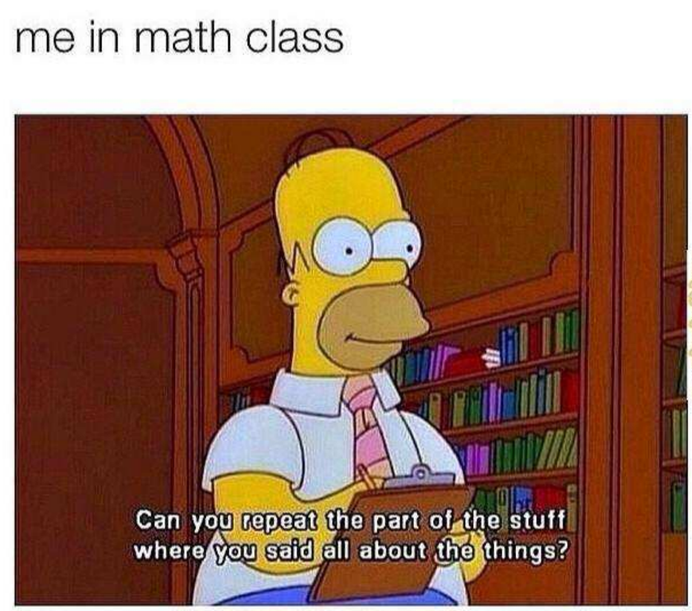
<tr><td>20</td><td>
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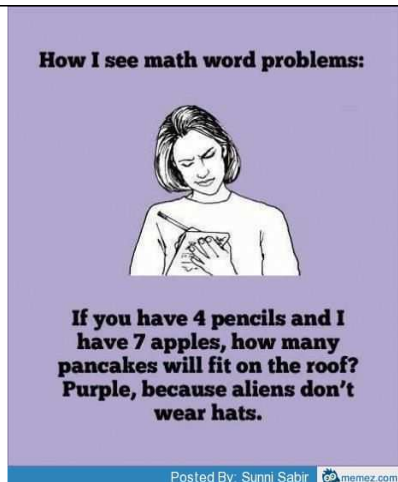
<tr><td>21</td><td>
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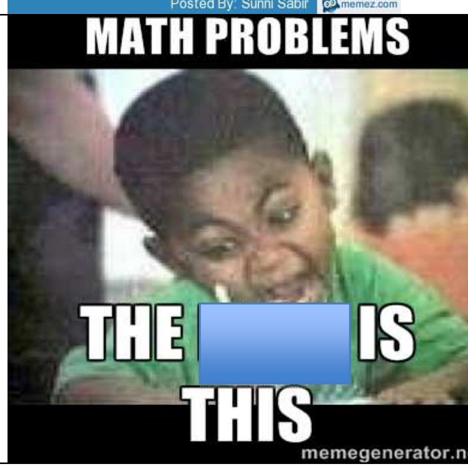
<tr><td>22</td><td>
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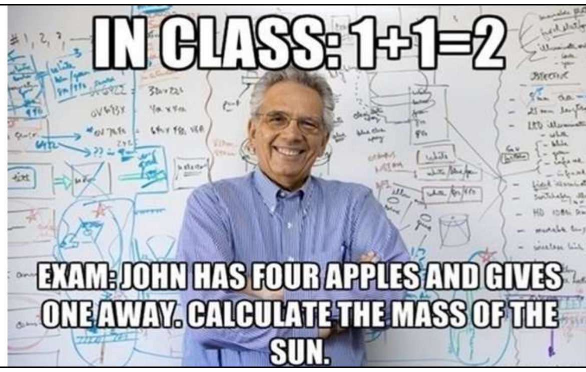
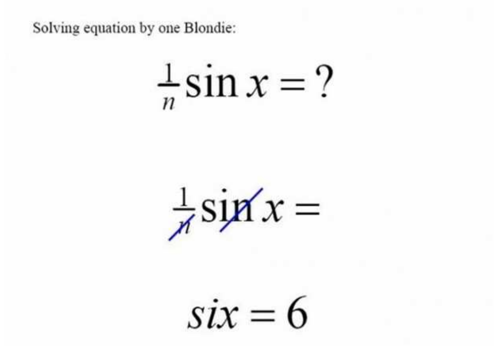
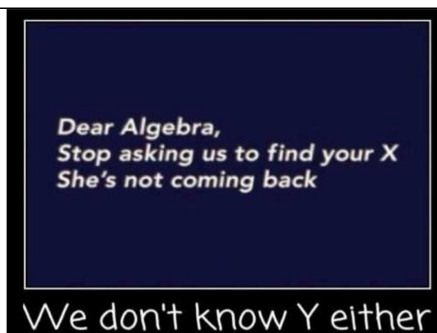
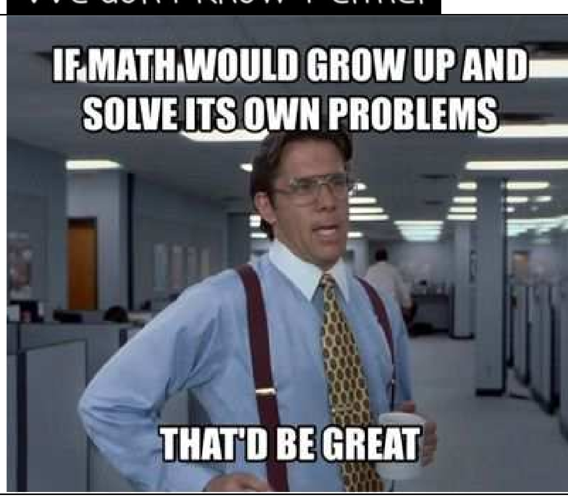
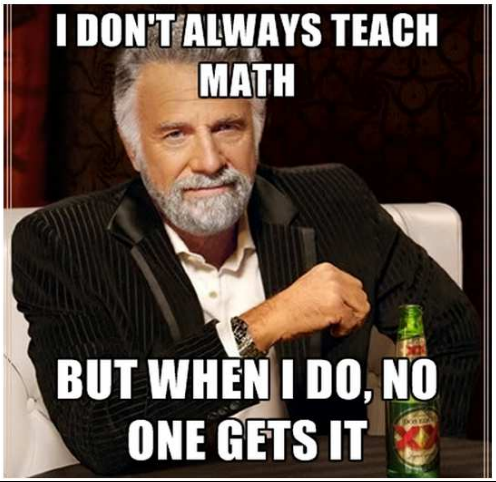
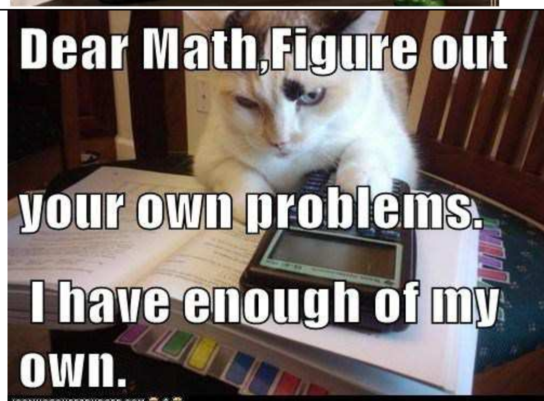
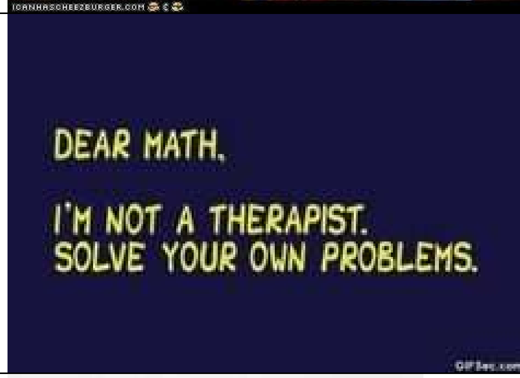
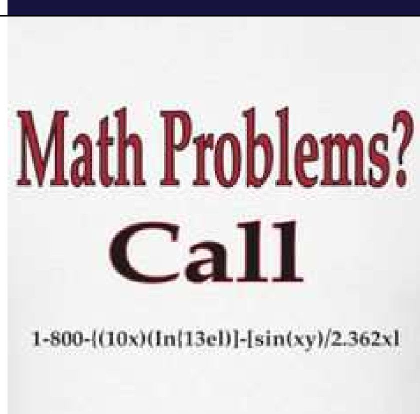
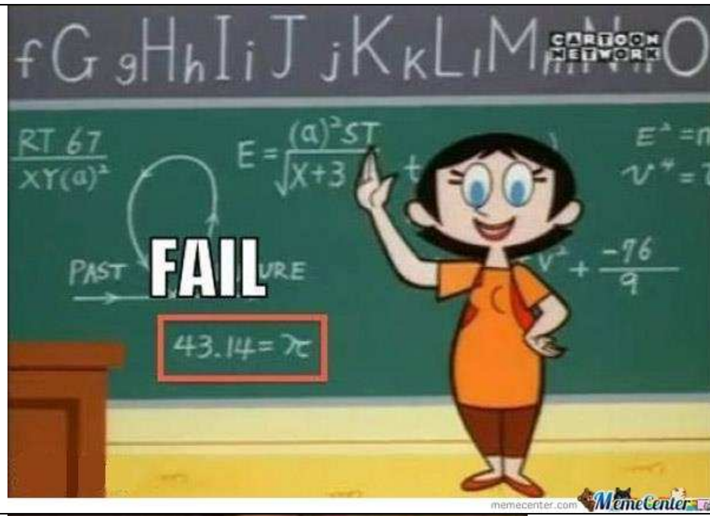
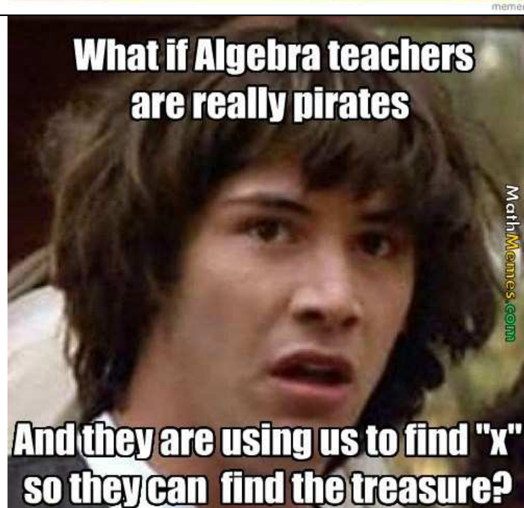
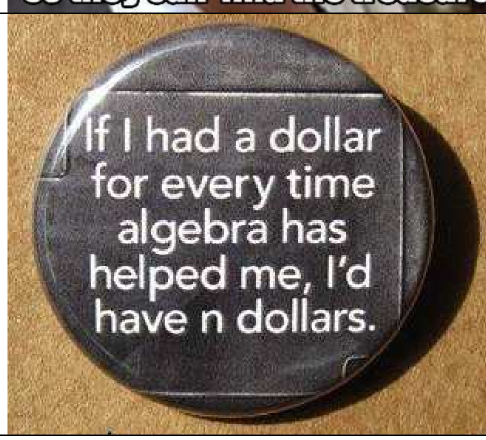
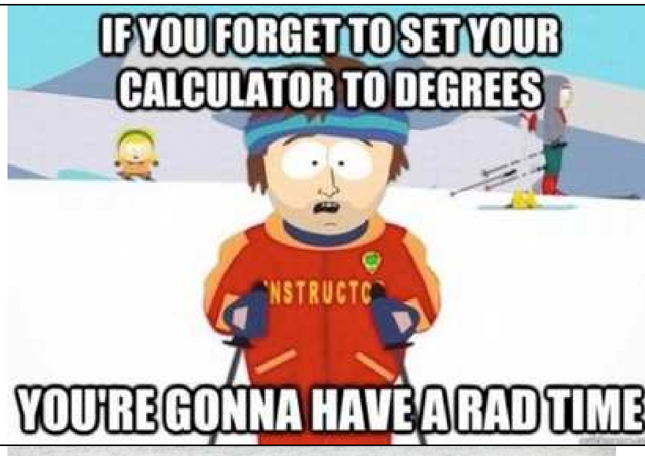
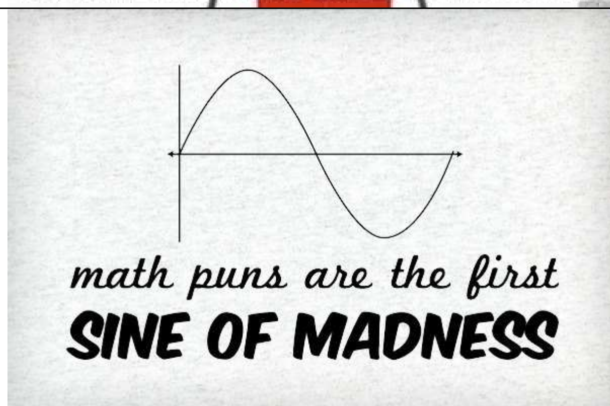
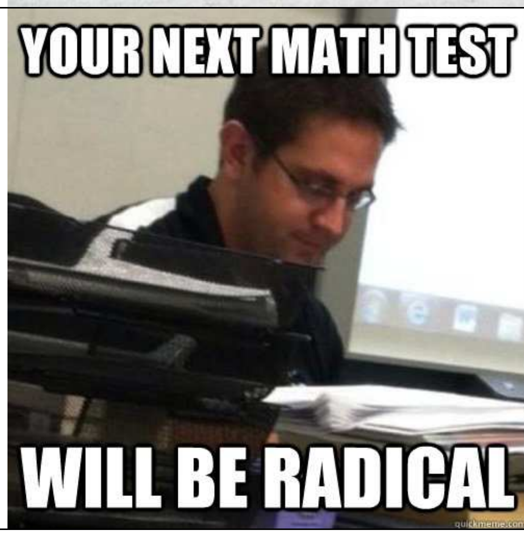
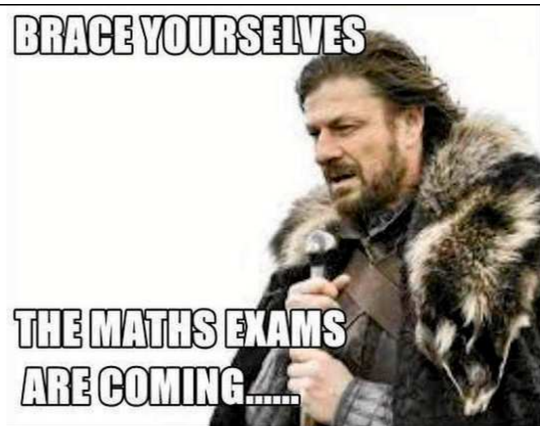
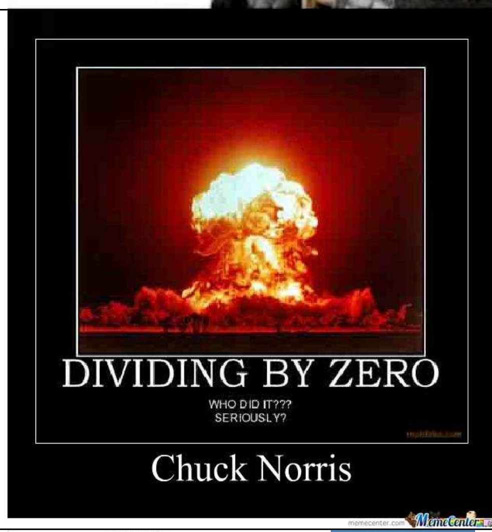
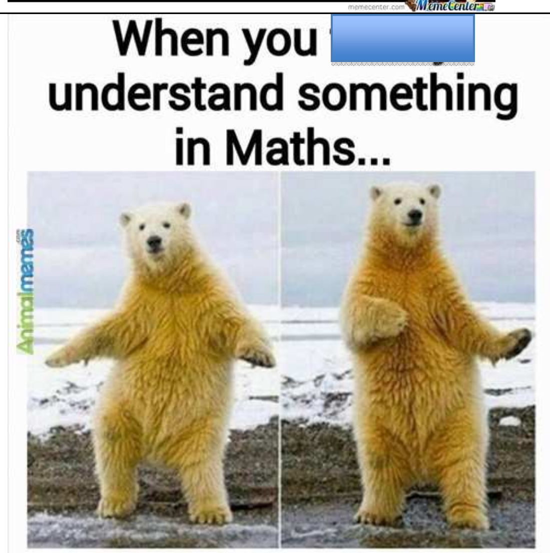
23		Suggestion:
24		Suggestion:

25		Suggestion:
26		Suggestion:

27		Suggestion:
28		Suggestion:
29		Suggestion:
30		Suggestion:

31		Suggestion:
32		Suggestion:
33		Suggestion:

34		Suggestion:
35		Suggestion:
36		Suggestion:

37		Suggestion:
38		Suggestion:
39		Suggestion:

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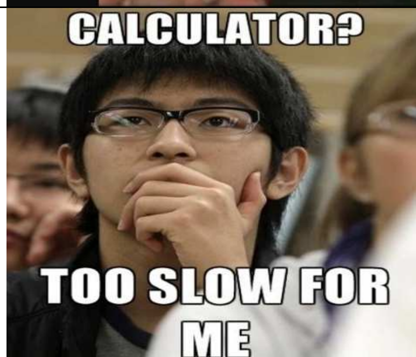
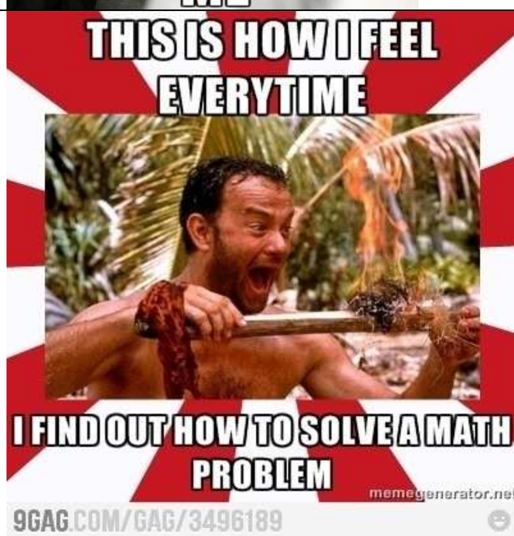
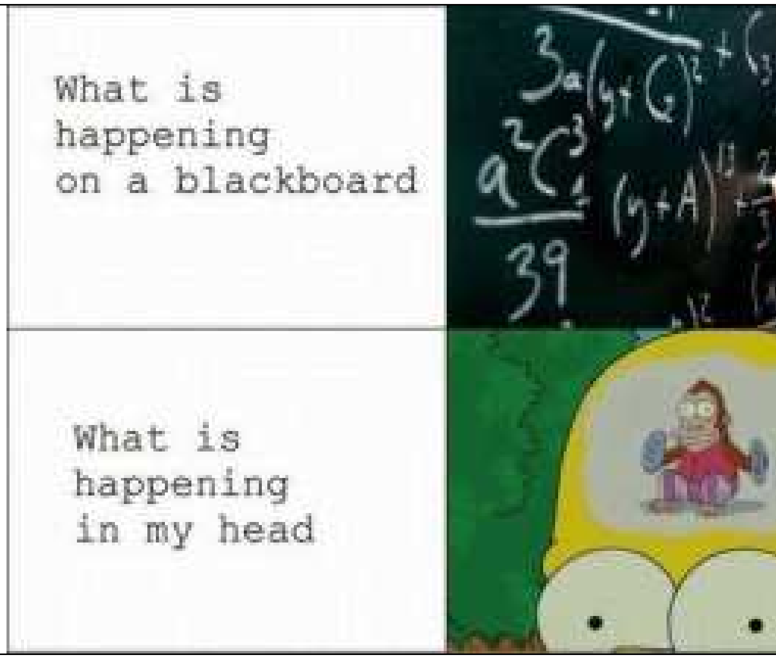
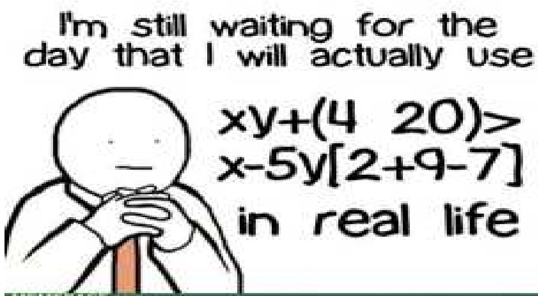
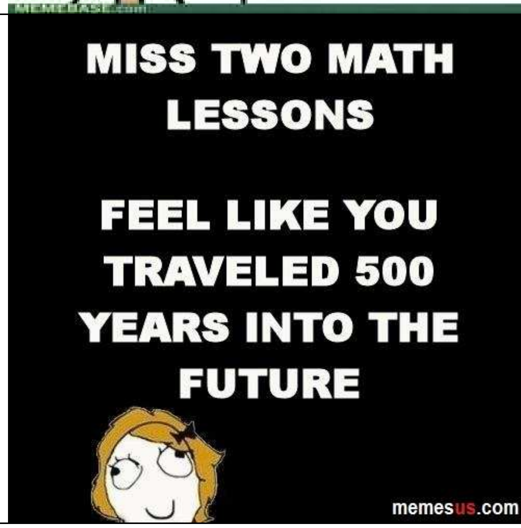
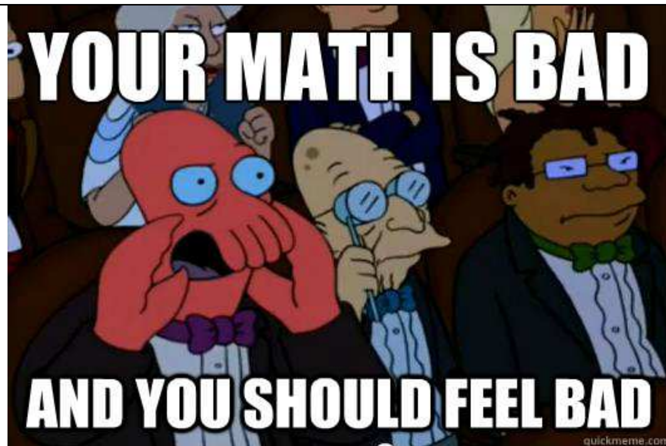
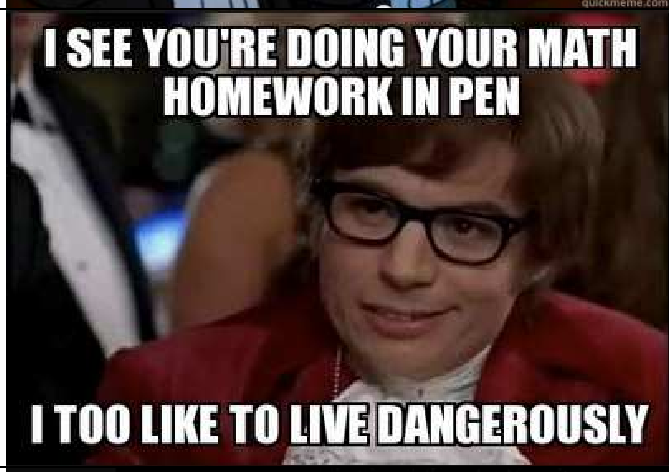
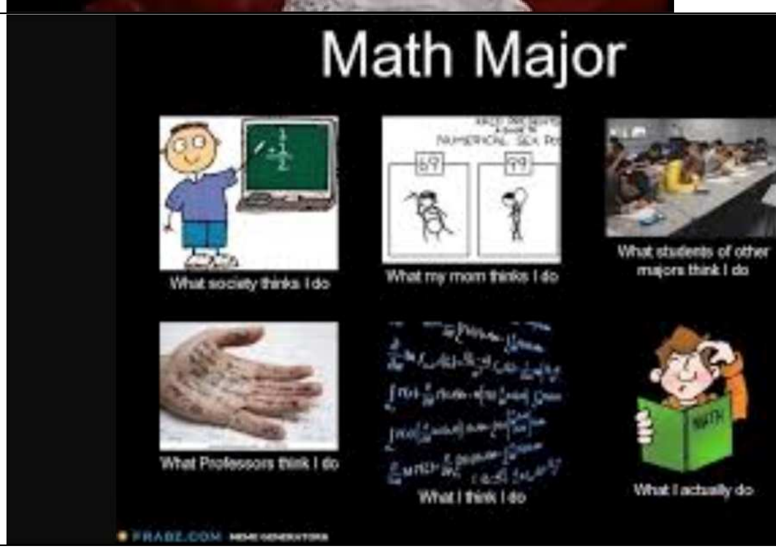
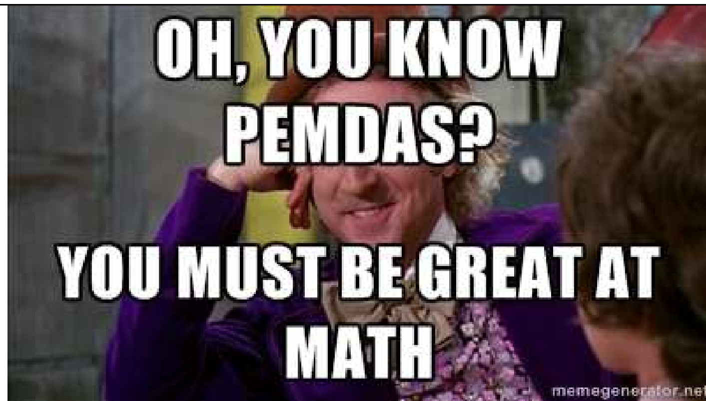
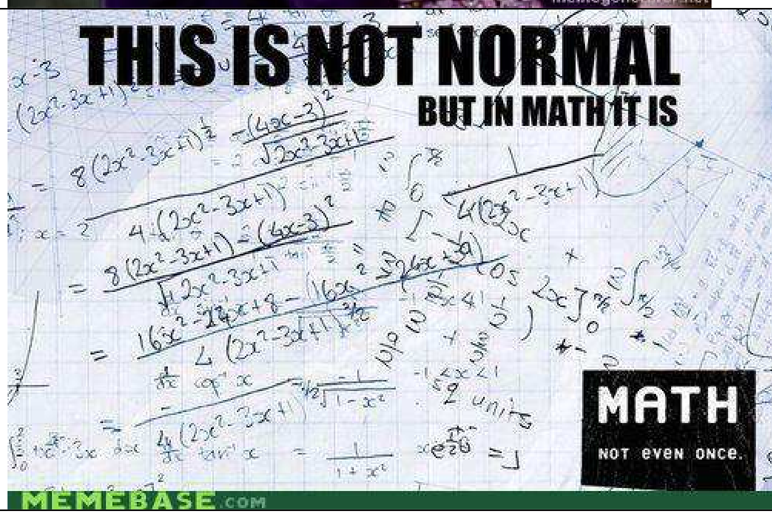
41		Suggestion:
42		Suggestion:

43		Suggestion:
44		Suggestion:
45		Suggestion:

46			Suggestion:
47			Suggestion:
48			Suggestion:

49		Suggestion:
50		Suggestion:

Appendix K

Completed Meme Inventory Tally Sheet

Meme	DD	JV	FM	RJ	LZ	BD	AS	EM	NF	KD
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2	P	P	P	P	O	P	P	P	P	P
3	N	N	P	P	N	N	O	N	N	P
4	P	P	P	N	U	P	P	P	P	P
5	N	N	N	N	N	N	P	P	N	P
6	N	N	N	N	U	O	O	N	O	N
7	N	O	N	N	N	N	O	P	O	P
8	N	N	N	N	N	N	N	P	O	O
9	N	N	N	N	N	N	O	N	N	N
10	N	N	N	N	N	N	N	N	N	P
11	N	N	N	N	N	N	N	N	N	N
12	N	N	N	N	N	N	N	N	N	N
13	O	N	N	N	N	N	N	N	N	P
14	P	O	N	N	O	O	U	P	P	N
15	N	N	N	N	N	U	U	N	P	N
16	N	N	N	N	N	N	N	N	N	N
17	N	N	N	N	N	N	N	N	N	P
18	N	N	N	N	N	N	N	N	N	O
19	O	O	O	O	O	O	O	P	O	O
20	N	N	N	N	O	N	N	N	O	N
21	N	N	N	N	N	N	N	N	N	P
22	N	N	N	N	N	N	O	N	O	P

23	N	O	N	N	N	N	N	N	N	P
24	U	O	N	O	O	N	O	N	N	O
25	P	P	P	N	O	N	O	P	P	P
26	O	O	N	N	O	O	O	O	O	O
27	N	N	N	N	N	N	N	N	N	P
28	N	O	N	N	N	N	N	N	O	P
29	N	O	N	N	N	N	N	N	O	P
30	N	P	N	N	O	N	O	O	O	P
31	U	U	N	U	U	N	O	N	O	N
32	U	O	N	N	O	O	O	O	O	P
33	U	O	N	N	U	O	P	P	P	P
34	O	O	O	O	O	P	P	U	P	P
35	N	O	N	O	O	P	P	P	P	P
36	P	P	P	O	O	P	P	P	P	P
37	N	O	N	N	N	N	U	P	O/P	O
38	O	O	U	O	O	N	P	P	U	P
39	P	P	P	N	P	N	P	P	P	P
40	N	O	N	N	U	N	U	N	U	N
41	U	U	N	U	N	N	N	O	N	P
42	P	P	P	N	P	N	P	P	P	P
43	N	N	N	N	N	N	N	N	N	O
44	N	O	N	N	N	N	N	N	N	P
45	N	O	N	N	U	N	O	U	O	P
46	N	N	N	N	N	N	U	U	U	U
47	O	O	U	O	O	O	O	P	P	O
48	N	O	N	N	O	N	P	U	O	U
49	U	U	N	O	U	O	U	P	O	P
50	N	O	N	N	N	N	U	N	N	P

Appendix L

Descriptive Statistics Table

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Self Preceived Math Ability	31	7.00	3.00	10.00	7.6935	1.49821	2.245
Meme1	31	2.00	1.00	3.00	1.7742	.66881	.447
Meme2	31	2.00	1.00	3.00	1.3226	.59928	.359
Meme3	31	2.00	1.00	3.00	2.2258	.71692	.514
Meme4	30	2.00	1.00	3.00	2.6333	.61495	.378
Meme5	30	2.00	1.00	3.00	1.7333	.73968	.547
Meme6	31	2.00	1.00	3.00	2.0000	.73030	.533
Meme7	30	2.00	1.00	3.00	1.8333	.83391	.695
Meme8	31	2.00	1.00	3.00	2.4516	.76762	.589
Meme9	31	2.00	1.00	3.00	2.4194	.71992	.518
Valid N (listwise)	29						